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Mizutani

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(54) **COMMUNICATION NETWORK SYSTEM AND COMMUNICATION NETWORK CONFIGURATION METHOD**

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(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 210 days.

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(22) PCT Filed: **Oct. 28, 2011**

(86) PCT No.: **PCT/JP2011/074954**

§ 371 (c)(1),
(2), (4) Date: **Jun. 13, 2013**

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PCT Pub. Date: **Aug. 30, 2012**

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(30) **Foreign Application Priority Data**

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(51) **Int. Cl.**
H04L 12/24 (2006.01)
H04L 12/707 (2013.01)
H04L 12/703 (2013.01)
H04L 12/753 (2013.01)

(52) **U.S. Cl.**
CPC ***H04L 41/0668*** (2013.01); ***H04L 45/22*** (2013.01); ***H04L 45/28*** (2013.01); ***H04L 45/48*** (2013.01)

(58) **Field of Classification Search**
None
See application file for complete search history.

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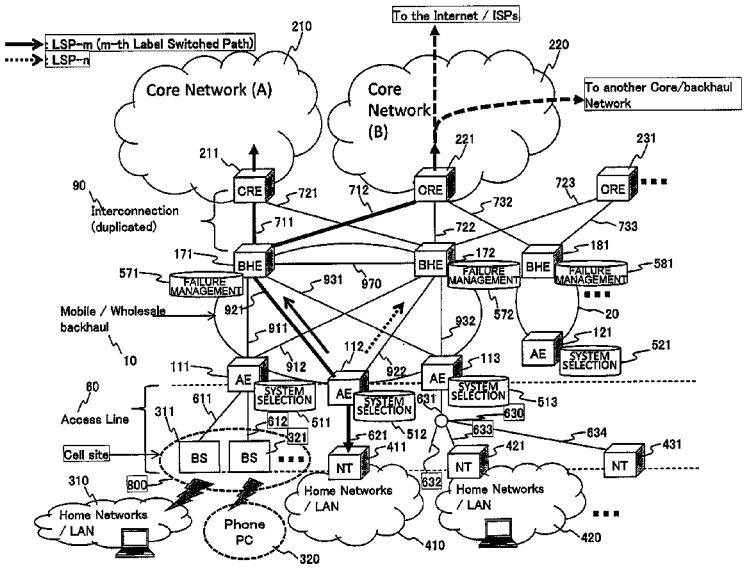
Primary Examiner — Christine Duong
(74) *Attorney, Agent, or Firm* — Volpe and Koenig, P.C.

(57) **ABSTRACT**

A redundant path configuration method and a control method are disclosed. An intercommunication path for mutually transmitting and receiving a signal is provided among the BHEs each of which is a top of a tree. When failures occur in an active system path in certain AE, a standby system path (BHE) relays communication between the AE and the (active system) BHE so as to secure continuity of communication. The intercommunication path through which a data signal does not flow in a normal operation is used as a traffic accommodation path in an emergency among the BHEs. By setting a bypass between the tops of the trees, when a failure occurs in one tree, a signal is transferred from the active system BHE to the standby system path in which another BHE is a top to build a sub-tree bypassing the failure point and to secure a communication path.

10 Claims, 37 Drawing Sheets



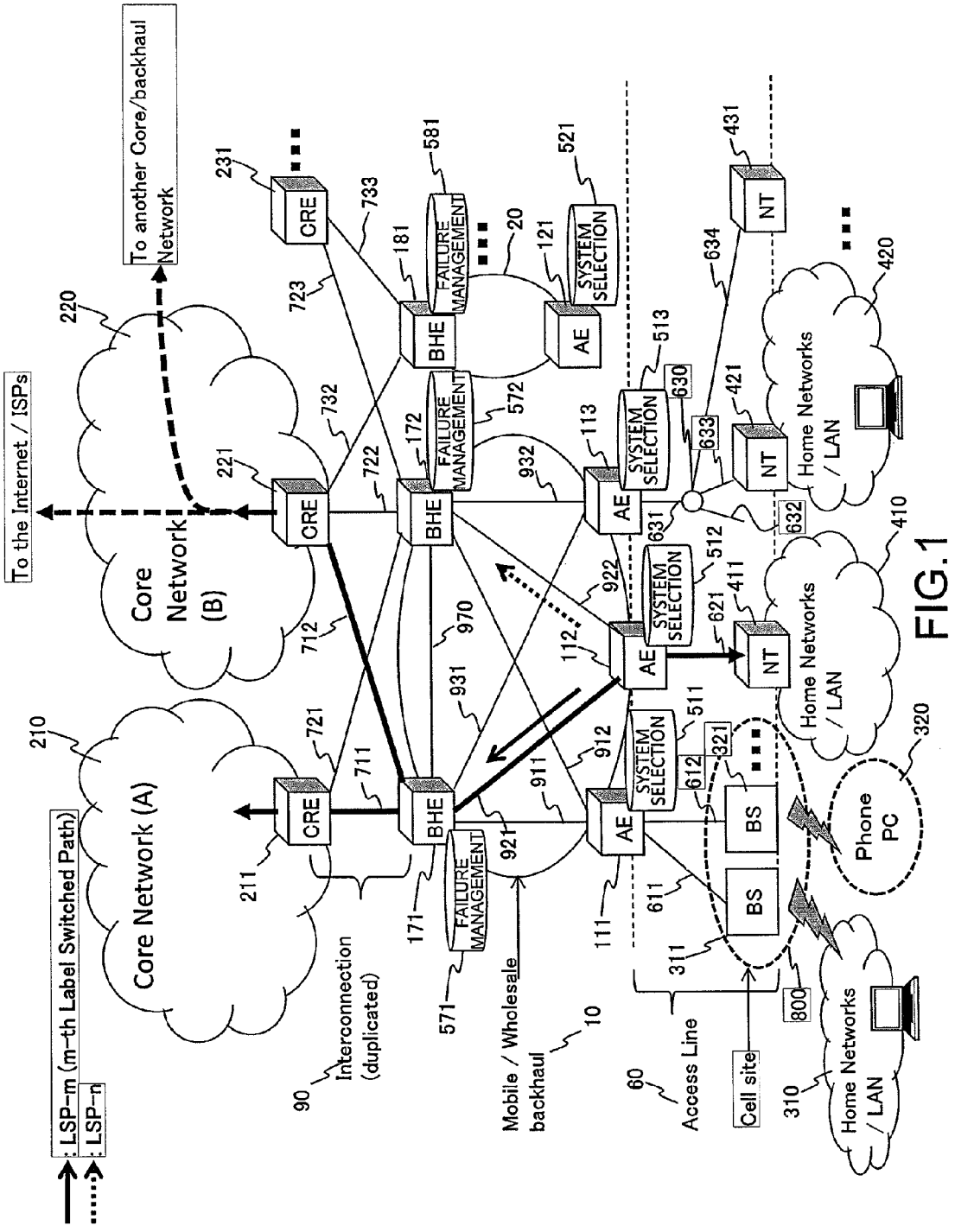

LSP-m (m-th Label Switched Path)
LSP-n
To the Internet / ISPs
To another Core/backhaul Network
Core Network (A)
Core Network (B)
CRE
BHE
AE
NT
BS
FAILURE MANAGEMENT
SYSTEM SELECTION
Home Networks / LAN
Phone PC
Interconnection (duplicated)
Mobile / Wholesale backhaul
Access Line
Cell site

FIG.1

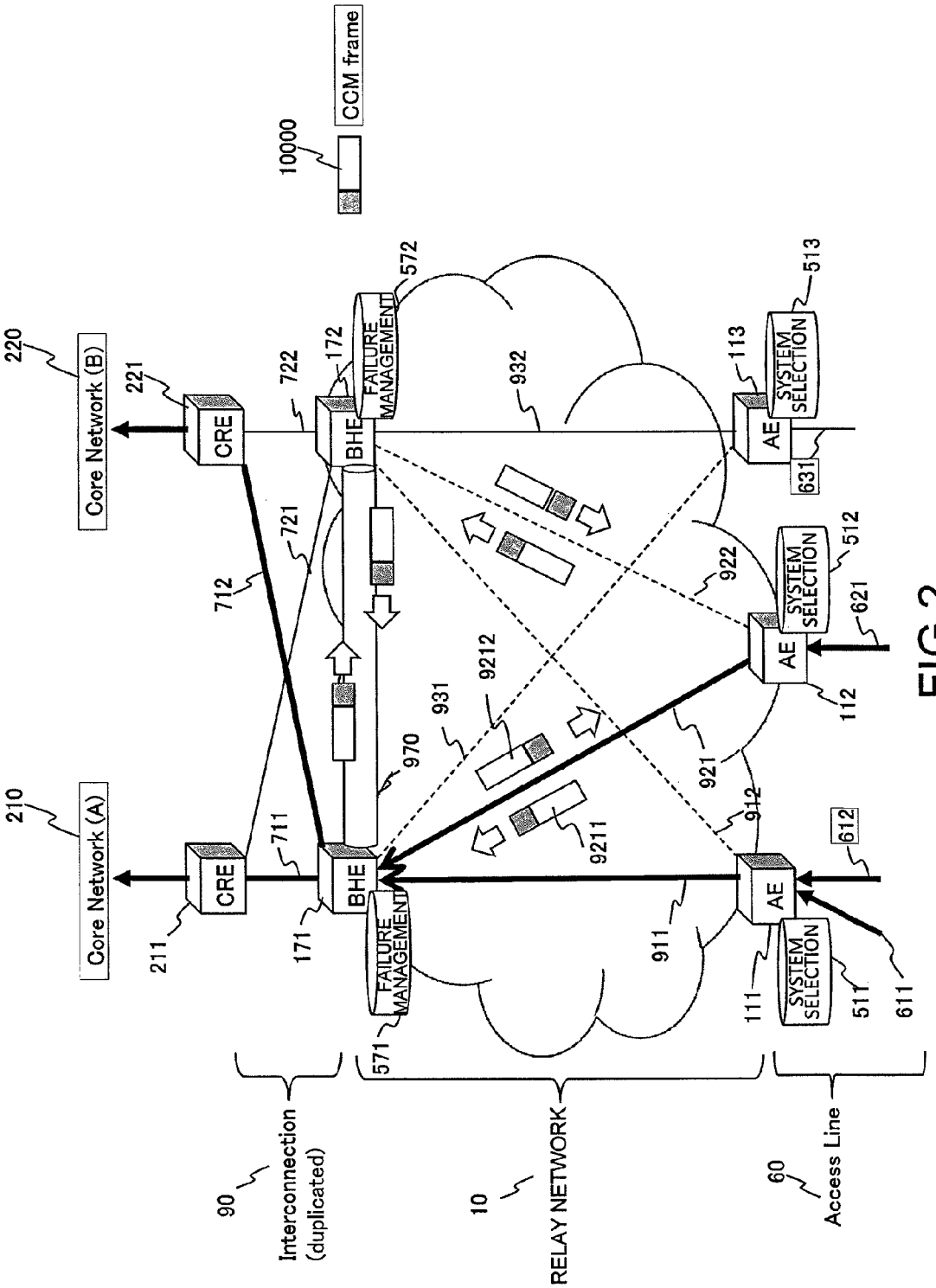

10000
CCM frame
220
Core Network (B)
221
CRE
722
172
BHE
FAILURE MANAGEMENT
572
932
113
AE
SYSTEM SELECTION
513
631
721
712
922
512
621
931
9212
112
970
921
912
210
Core Network (A)
711
9211
612
211
171
911
111
511
611
571
90
Interconnection (duplicated)
10
RELAY NETWORK
60
Access Line

FIG.2

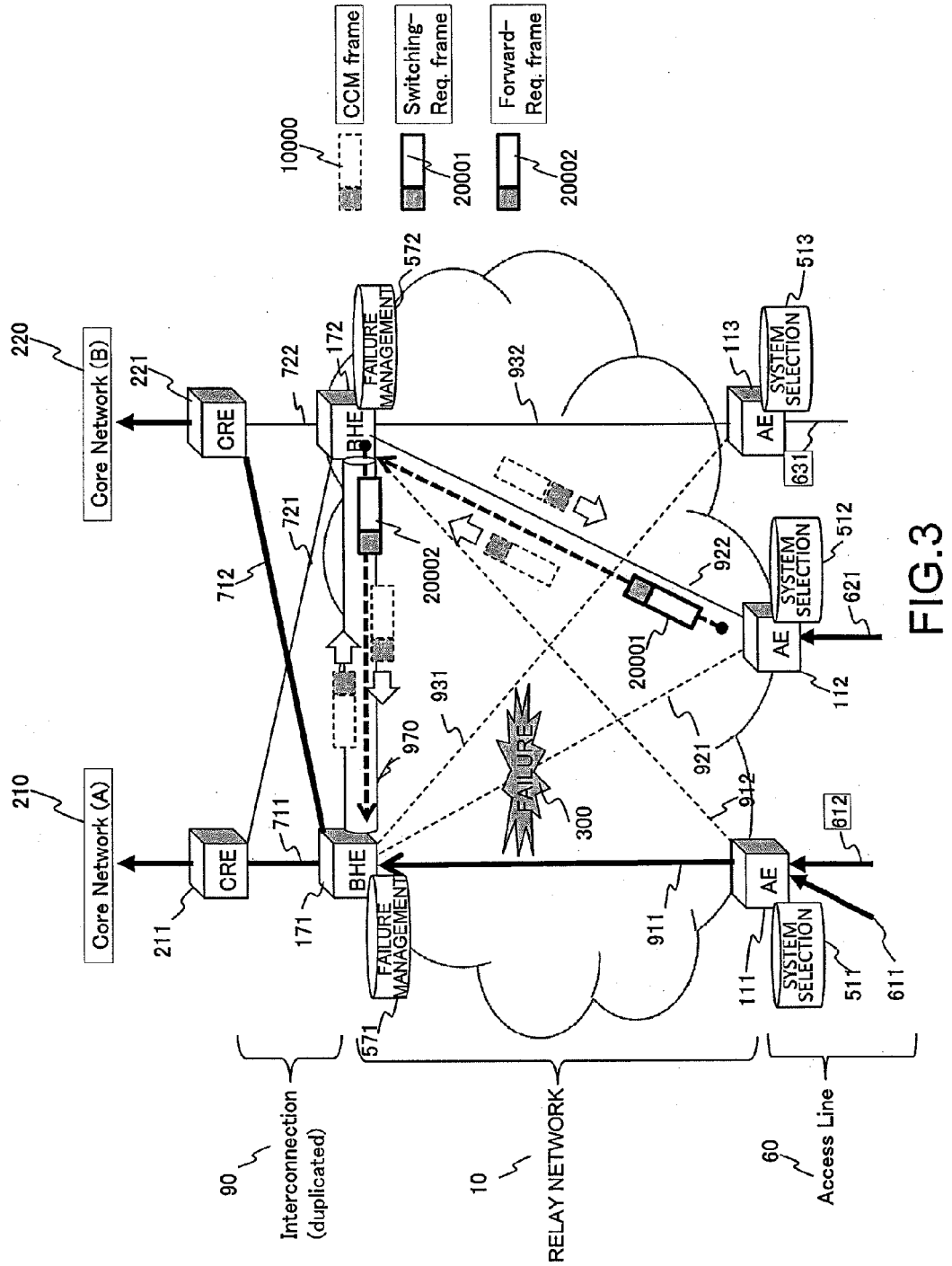

10000
CCM frame
Switching-Req. frame
20001
Forward-Req. frame
20002
220
Core Network (B)
221
CRE
722
172
FAILURE MANAGEMENT
572
932
113
SYSTEM SELECTION
513
AE
631
712
721
20002
922
512
SYSTEM SELECTION
621
AE
112
20001
931
970
FAILURE
300
921
912
210
Core Network (A)
CRE
711
BHE
612
211
171
FAILURE MANAGEMENT
911
111
SYSTEM SELECTION
511
611
571
90
Interconnection (duplicated)
10
RELAY NETWORK
60
Access Line

FIG.3

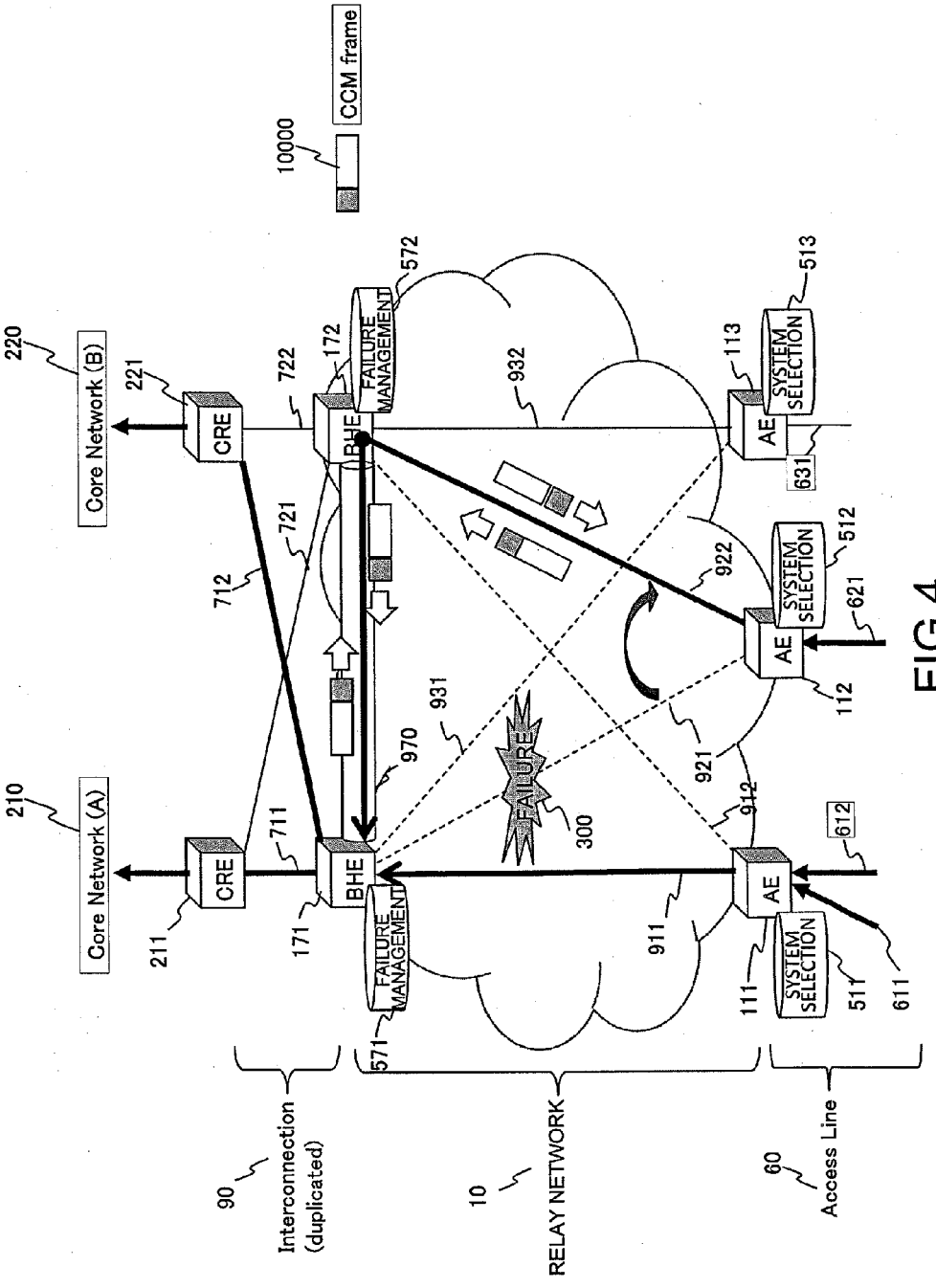

10000
CCM frame
220
Core Network (B)
221
CRE
722
172
BHE
FAILURE MANAGEMENT
572
932
113
AE
SYSTEM SELECTION
513
631
712
721
922
512
SYSTEM SELECTION
621
AE
112
931
970
FAILURE
300
921
912
210
Core Network (A)
211
CRE
711
171
BHE
FAILURE MANAGEMENT
571
911
AE
612
111
SYSTEM SELECTION
511
611
90
Interconnection (duplicated)
10
RELAY NETWORK
60
Access Line

FIG.4

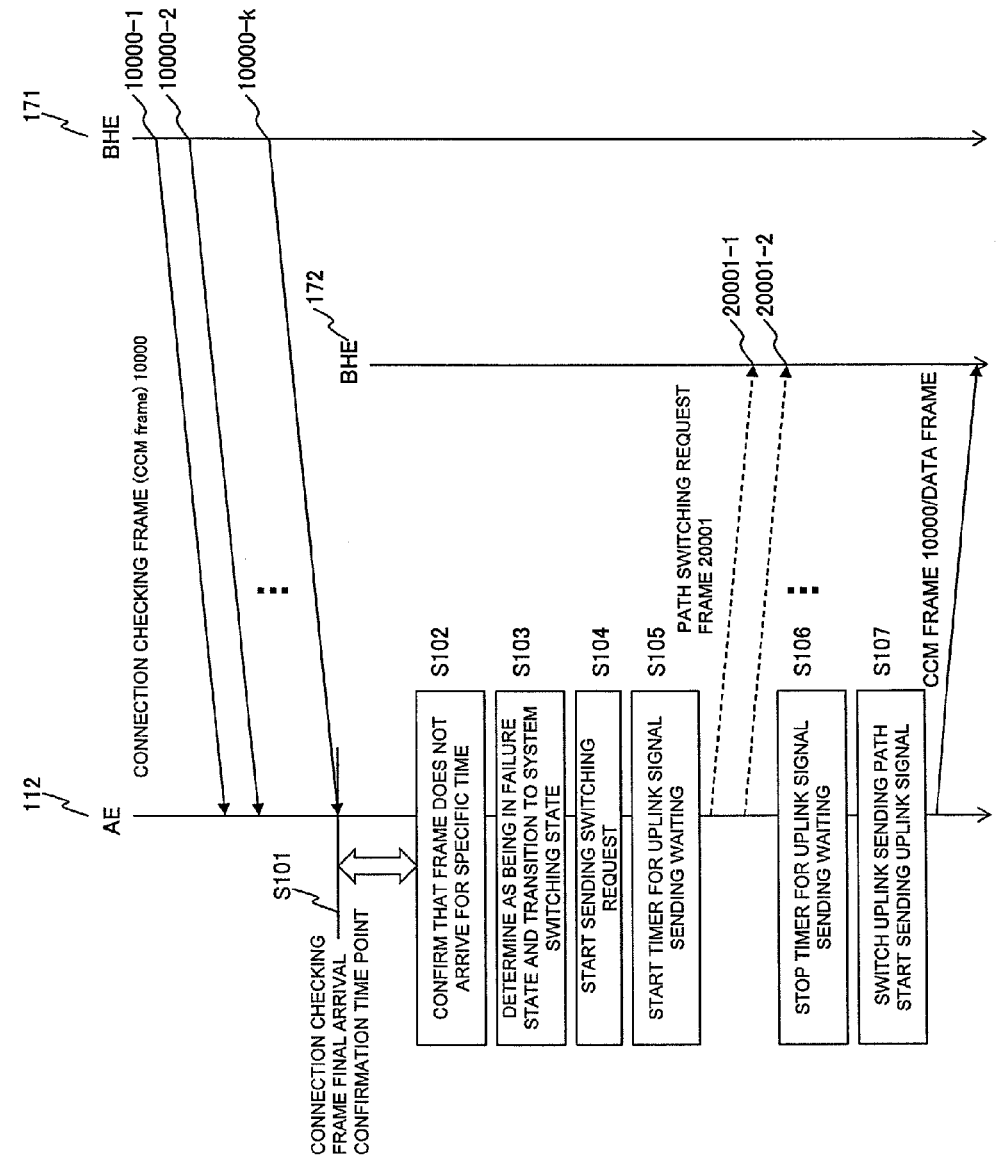

112
AE
171
BHE
10000-1
10000-2
10000-k
CONNECTION CHECKING FRAME (CCM frame) 10000
172
BHE
20001-1
20001-2
S101
CONNECTION CHECKING FRAME FINAL ARRIVAL CONFIRMATION TIME POINT
S102
CONFIRM THAT FRAME DOES NOT ARRIVE FOR SPECIFIC TIME
S103
DETERMINE AS BEING IN FAILURE STATE AND TRANSITION TO SYSTEM SWITCHING STATE
S104
START SENDING SWITCHING REQUEST
S105
START TIMER FOR UPLINK SIGNAL SENDING WAITING
PATH SWITCHING REQUEST FRAME 20001
S106
STOP TIMER FOR UPLINK SIGNAL SENDING WAITING
S107
SWITCH UPLINK SENDING PATH START SENDING UPLINK SIGNAL
CCM FRAME 10000/DATA FRAME

FIG.5

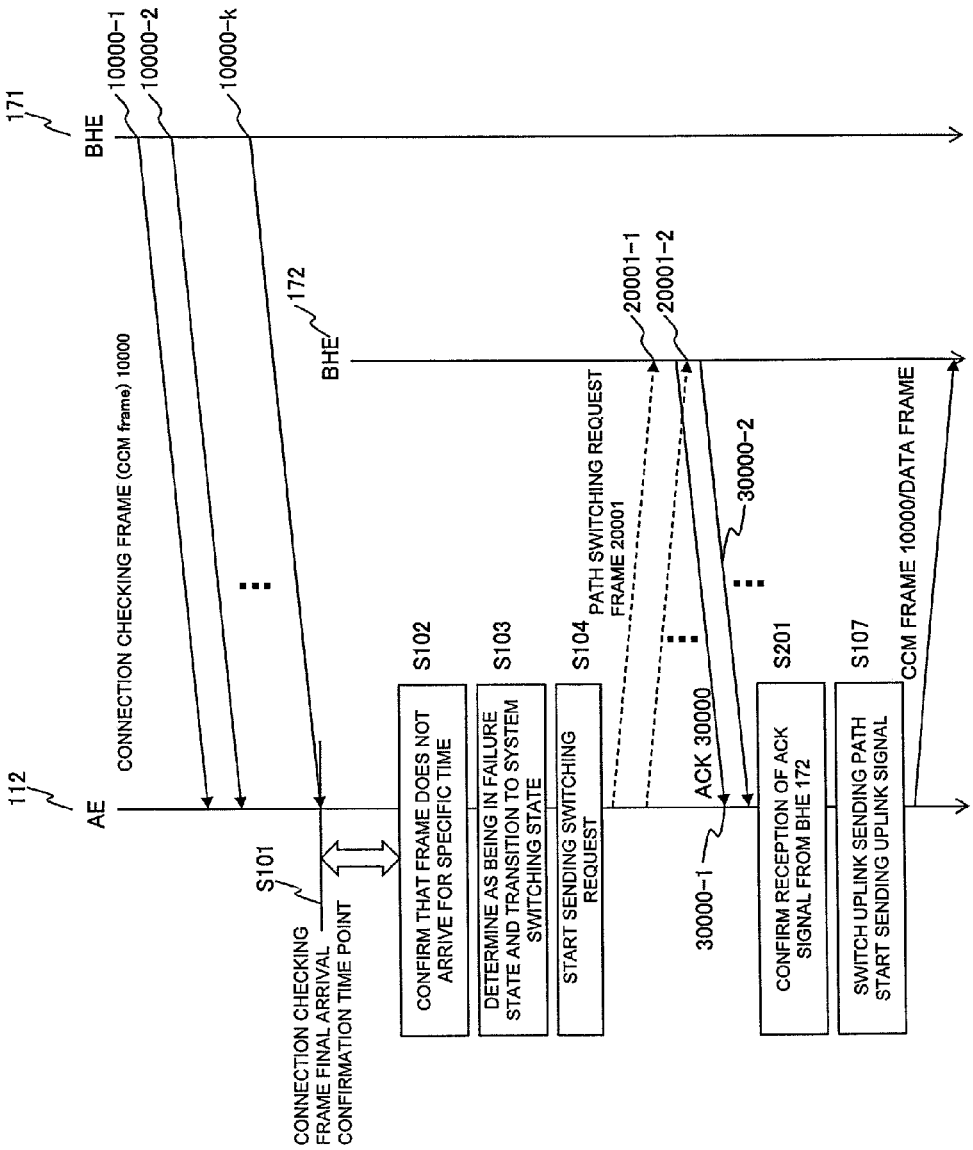

112
AE
171
BHE
10000-1
10000-2
10000-k
CONNECTION CHECKING FRAME (CCM frame) 10000
172
BHE
S101
CONNECTION CHECKING FRAME FINAL ARRIVAL CONFIRMATION TIME POINT
S102
CONFIRM THAT FRAME DOES NOT ARRIVE FOR SPECIFIC TIME
S103
DETERMINE AS BEING IN FAILURE STATE AND TRANSITION TO SYSTEM SWITCHING STATE
S104
START SENDING SWITCHING REQUEST
PATH SWITCHING REQUEST FRAME 20001
20001-1
20001-2
ACK 30000
30000-1
30000-2
S201
CONFIRM RECEPTION OF ACK SIGNAL FROM BHE 172
S107
SWITCH UPLINK SENDING PATH START SENDING UPLINK SIGNAL
CCM FRAME 10000/DATA FRAME

FIG.6

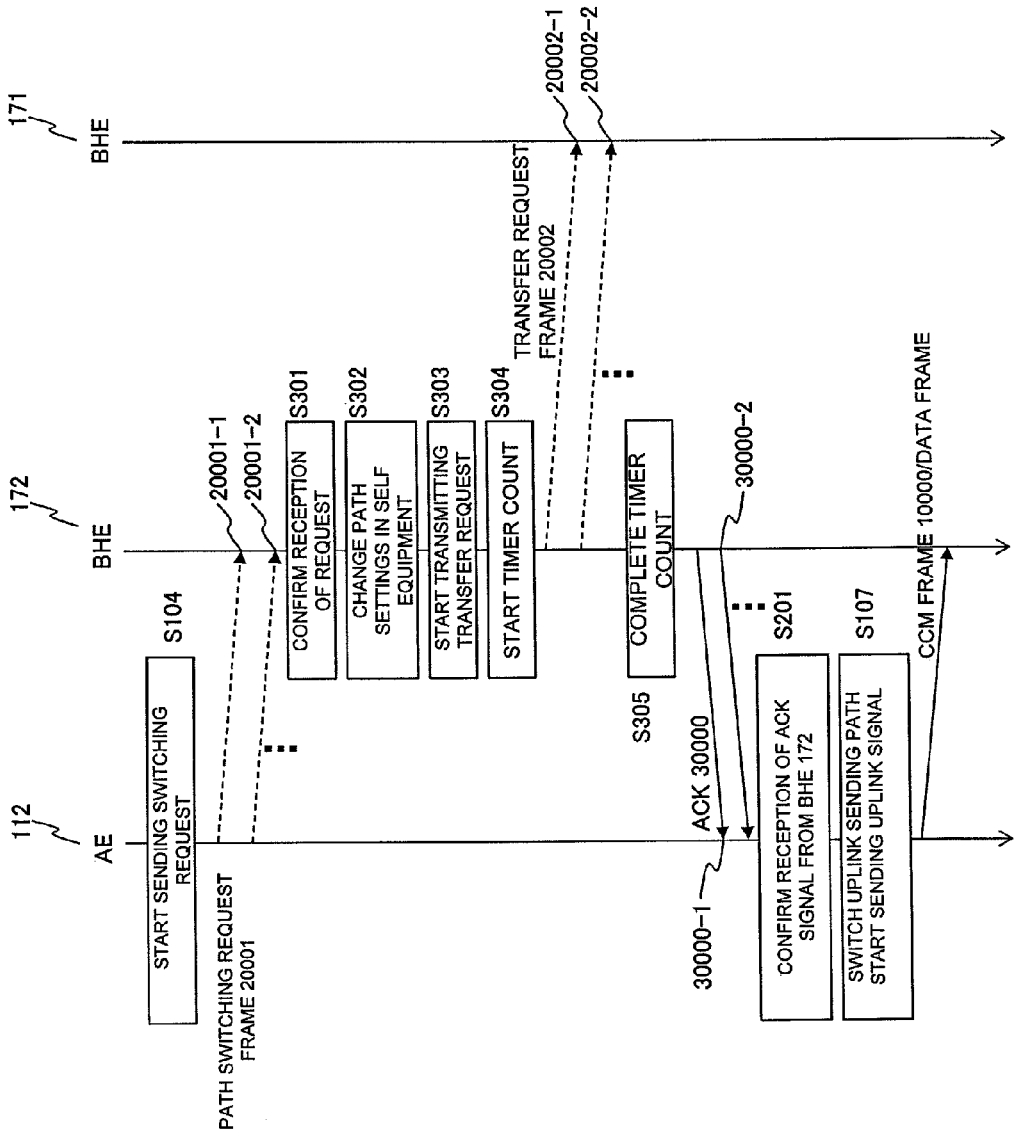

112
AE
171
BHE
172
BHE
START SENDING SWITCHING REQUEST
S104
PATH SWITCHING REQUEST FRAME 20001
20001-1
20001-2
CONFIRM RECEPTION OF REQUEST
S301
CHANGE PATH SETTINGS IN SELF EQUIPMENT
S302
START TRANSMITTING TRANSFER REQUEST
S303
START TIMER COUNT
S304
TRANSFER REQUEST FRAME 20002
20002-1
20002-2
COMPLETE TIMER COUNT
S305
ACK 30000
30000-1
30000-2
CONFIRM RECEPTION OF ACK SIGNAL FROM BHE 172
S201
SWITCH UPLINK SENDING PATH START SENDING UPLINK SIGNAL
S107
CCM FRAME 10000/DATA FRAME

FIG.7

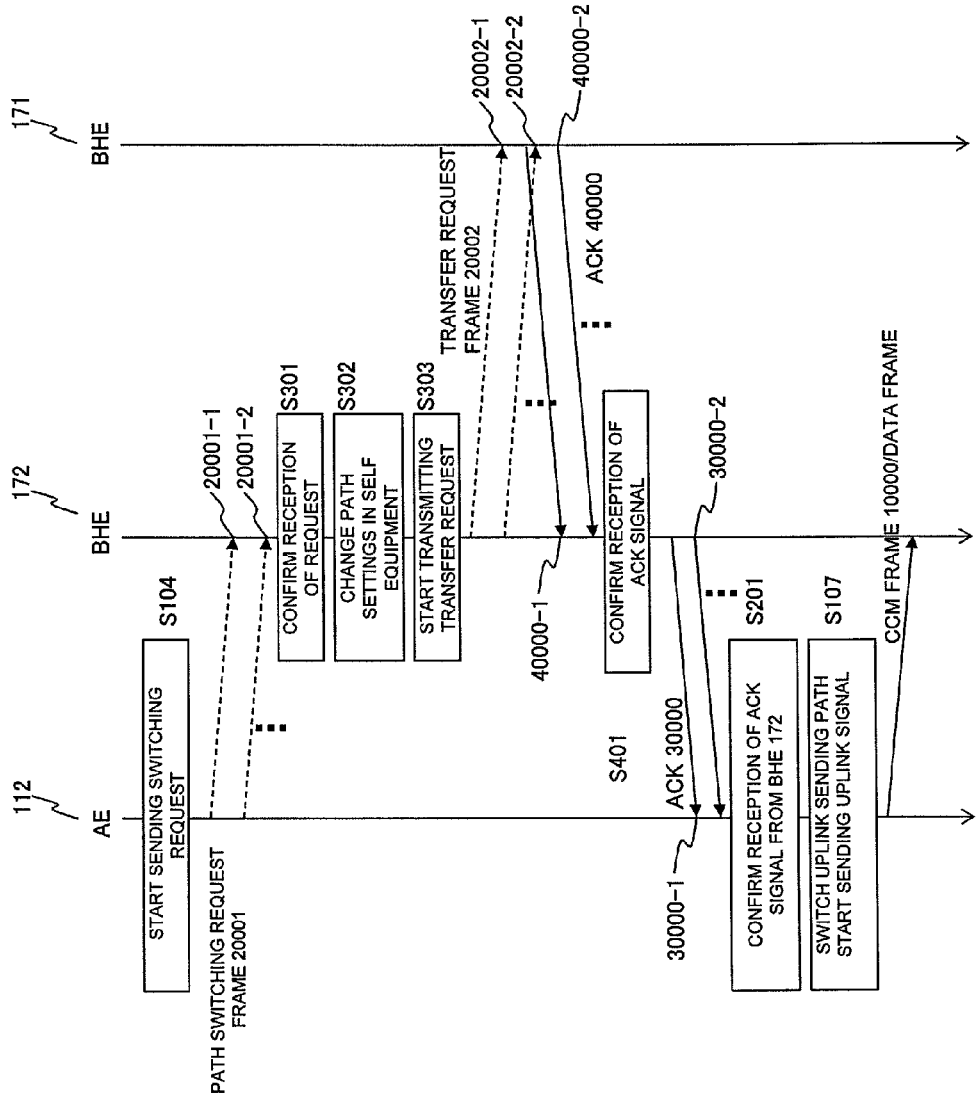

112
AE
171
BHE
172
BHE
START SENDING SWITCHING REQUEST
S104
PATH SWITCHING REQUEST FRAME 20001
20001-1
20001-2
S301
CONFIRM RECEPTION OF REQUEST
S302
CHANGE PATH SETTINGS IN SELF EQUIPMENT
S303
START TRANSMITTING TRANSFER REQUEST
TRANSFER REQUEST FRAME 20002
20002-1
20002-2
40000-2
ACK 40000
40000-1
CONFIRM RECEPTION OF ACK SIGNAL
S401
ACK 30000
30000-1
30000-2
S201
CONFIRM RECEPTION OF ACK SIGNAL FROM BHE 172
S107
SWITCH UPLINK SENDING PATH START SENDING UPLINK SIGNAL
CCM FRAME 10000/DATA FRAME

FIG.8

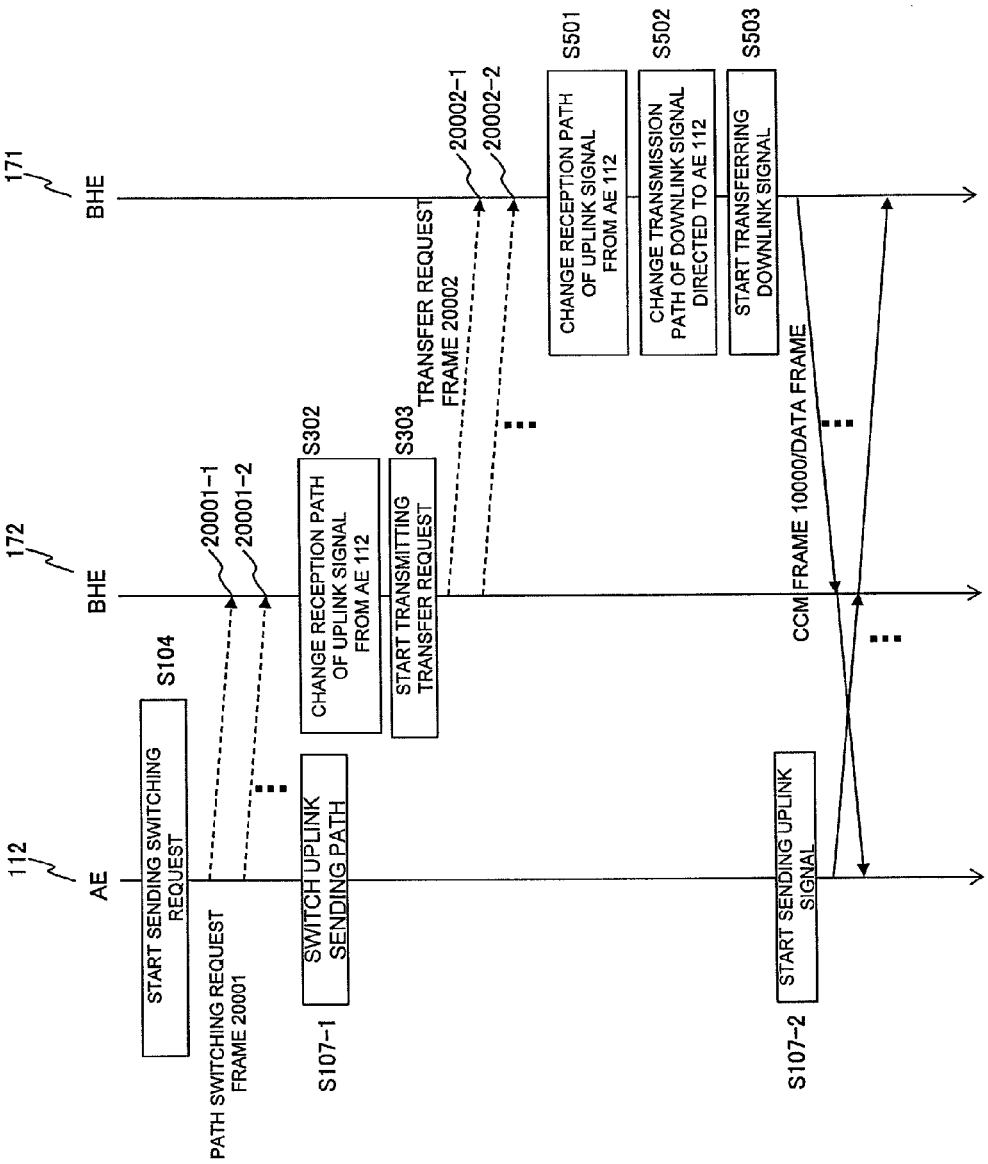

112
AE
171
BHE
172
BHE
START SENDING SWITCHING REQUEST
S104
PATH SWITCHING REQUEST FRAME 20001
20001-1
20001-2
SWITCH UPLINK SENDING PATH
S107-1
CHANGE RECEPTION PATH OF UPLINK SIGNAL FROM AE 112
S302
START TRANSMITTING TRANSFER REQUEST
S303
TRANSFER REQUEST FRAME 20002
20002-1
20002-2
CHANGE RECEPTION PATH OF UPLINK SIGNAL FROM AE 112
S501
CHANGE TRANSMISSION PATH OF DOWNLINK SIGNAL DIRECTED TO AE 112
S502
START TRANSFERRING DOWNLINK SIGNAL
S503
CCM FRAME 10000/DATA FRAME
START SENDING UPLINK SIGNAL
S107-2

FIG.9

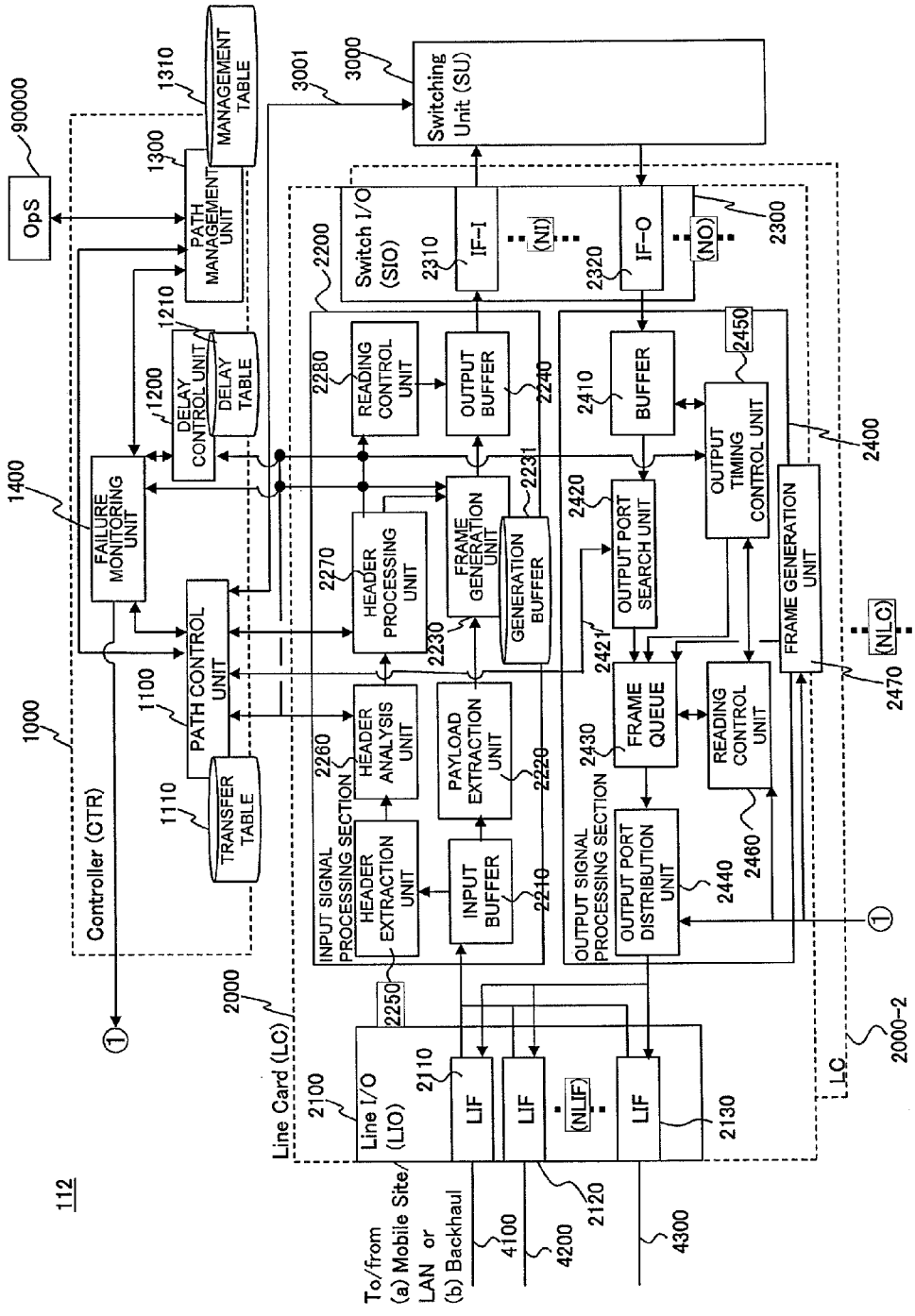

112
To/from (a) Mobile Site, LAN or (b) Backhaul
4100
4200
4300
2120
Line Card (LC)
2000
2000-2
LC
2100
Line I/O (LIO)
2110
LIF
NLIF
2130
2250
2210
INPUT BUFFER
HEADER EXTRACTION UNIT
2220
PAYLOAD EXTRACTION UNIT
2260
HEADER ANALYSIS UNIT
INPUT SIGNAL PROCESSING SECTION
2230
HEADER PROCESSING UNIT
2270
2231
FRAME GENERATION UNIT
GENERATION BUFFER
2240
OUTPUT BUFFER
2280
READING CONTROL UNIT
2200
Switch I/O (SIO)
2310
IF-I
NI
2320
IF-O
NO
2300
3000
Switching Unit (SU)
3001
1000
Controller (CTR)
1100
PATH CONTROL UNIT
1110
TRANSFER TABLE
1200
DELAY CONTROL UNIT
1210
DELAY TABLE
1300
PATH MANAGEMENT UNIT
1310
MANAGEMENT TABLE
1400
FAILURE MONITORING UNIT
90000
OpS
2421
2420
OUTPUT PORT SEARCH UNIT
2410
BUFFER
2450
OUTPUT TIMING CONTROL UNIT
2400
2430
FRAME QUEUE
READING CONTROL UNIT
2460
2440
OUTPUT PORT DISTRIBUTION UNIT
OUTPUT SIGNAL PROCESSING SECTION
FRAME GENERATION UNIT
2470
NLC

FIG.10

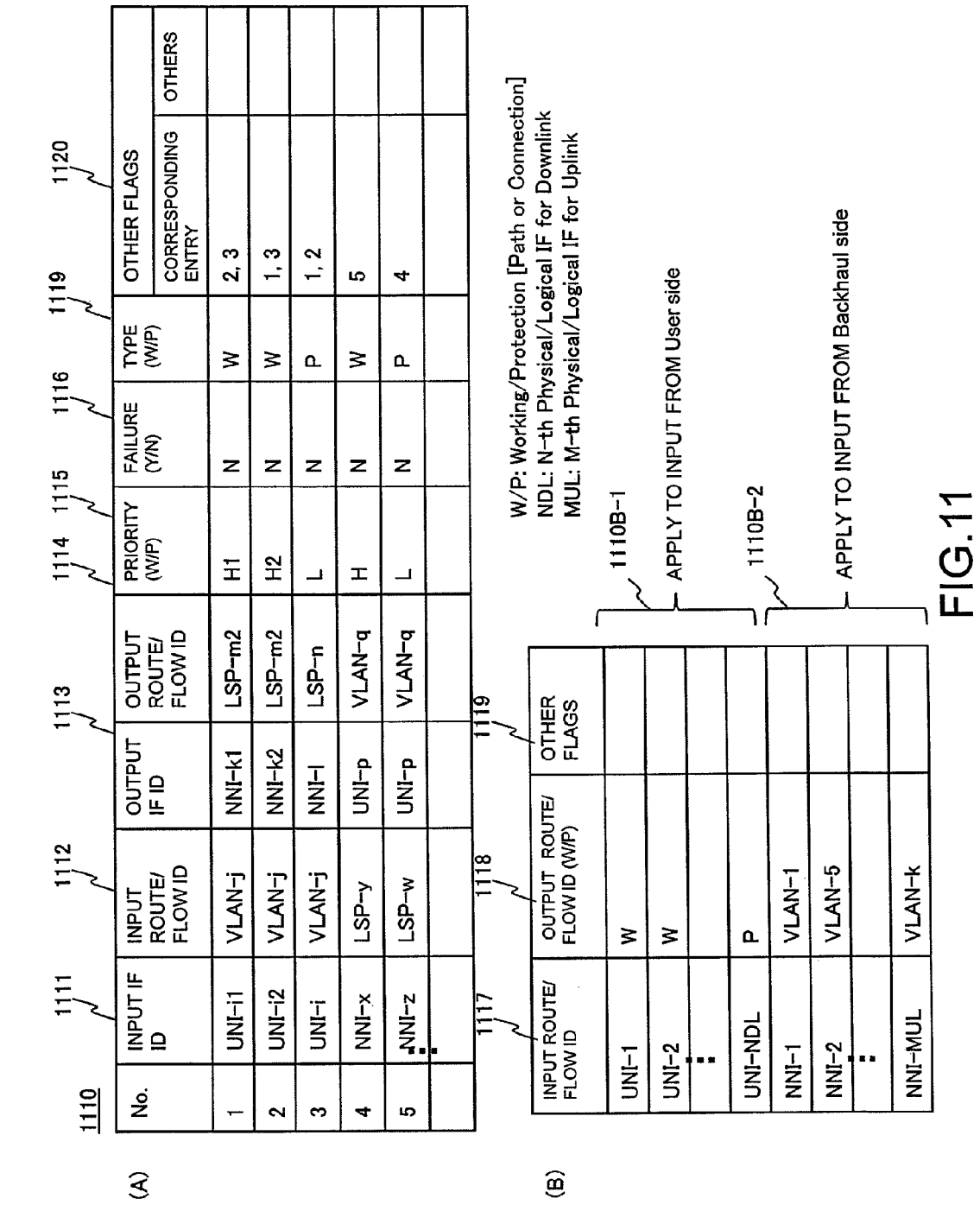
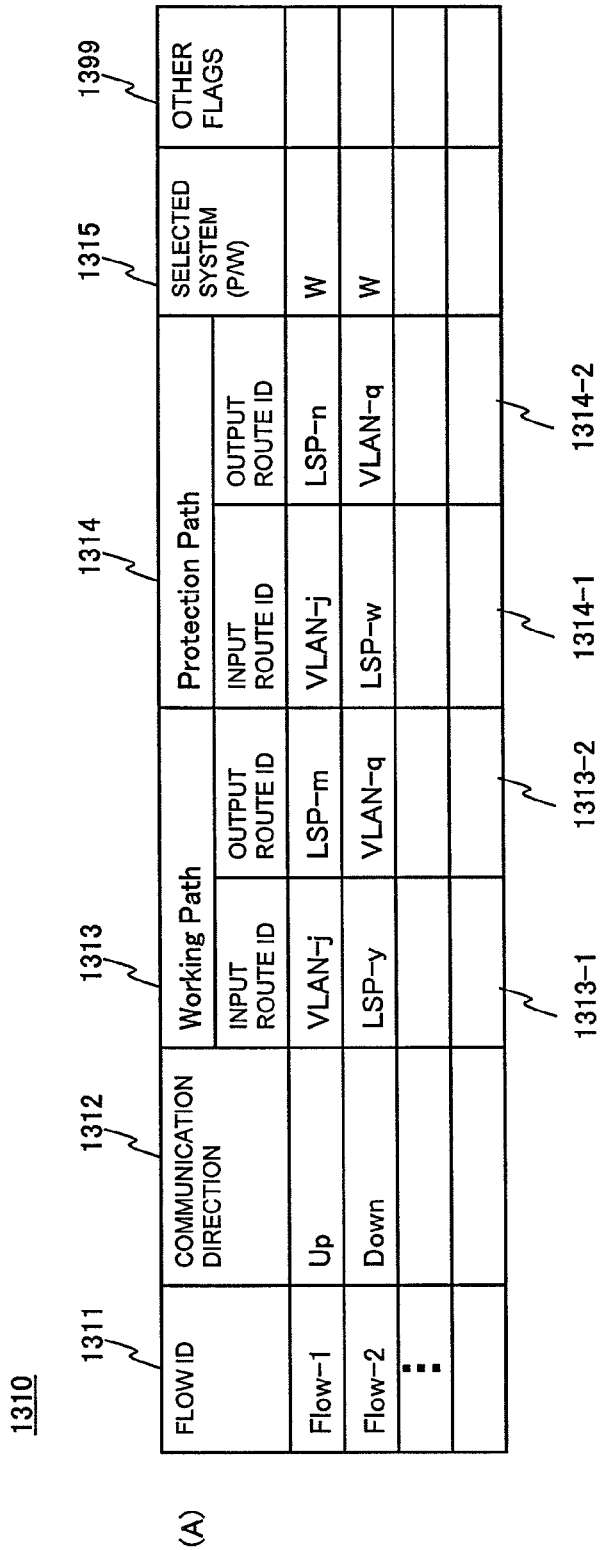

(A)
1110
1111
1112
1113
1114
1115
1116
1119
1120
No.
INPUT IF ID
INPUT ROUTE/ FLOW ID
OUTPUT IF ID
OUTPUT ROUTE/ FLOW ID
PRIORITY (W/P)
FAILURE (Y/N)
TYPE (W/P)
OTHER FLAGS
CORRESPONDING ENTRY
OTHERS
1 UNI-i1 VLAN-j NNI-k1 LSP-m2 H1 N W 2, 3
2 UNI-i2 VLAN-j NNI-k2 LSP-m2 H2 N W 1, 3
3 UNI-i VLAN-j NNI-l LSP-n L N P 1, 2
4 NNI-x LSP-y UNI-p VLAN-q H N W 5
5 NNI-z LSP-w UNI-p VLAN-q L N P 4
1117
1118
1119
(B)
W/P: Working/Protection [Path or Connection]
NDL: N-th Physical/Logical IF for Downlink
MUL: M-th Physical/Logical IF for Uplink
INPUT ROUTE/ FLOW ID
OUTPUT ROUTE/ FLOW ID (W/P)
OTHER FLAGS
UNI-1 W
UNI-2 W
UNI-NDL P
NNI-1 VLAN-1
NNI-2 VLAN-5
NNI-MUL VLAN-k
1110B-1
APPLY TO INPUT FROM User side
1110B-2
APPLY TO INPUT FROM Backhaul side

FIG.11


1310
1311
1312
1313
1314
1315
1399
FLOW ID
COMMUNICATION DIRECTION
Working Path
INPUT ROUTE ID
OUTPUT ROUTE ID
Protection Path
INPUT ROUTE ID
OUTPUT ROUTE ID
SELECTED SYSTEM (P/W)
OTHER FLAGS
Flow-1
Up
VLAN-j
LSP-m
VLAN-j
LSP-n
W
Flow-2
Down
LSP-y
VLAN-q
LSP-w
VLAN-q
W
1313-1
1313-2
1314-1
1314-2

(A)

FIG.12

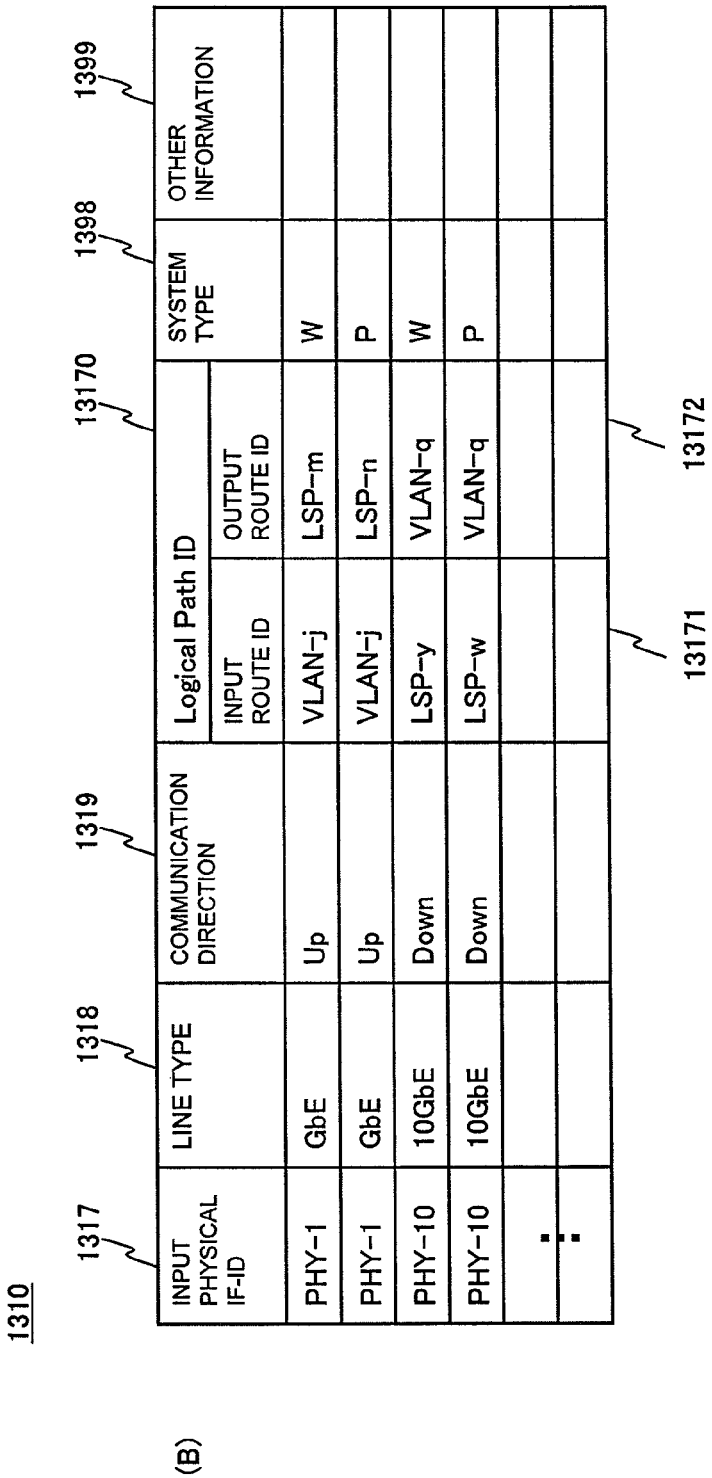

1310
(B)
1317
1318
1319
13170
1398
1399
13171
13172
INPUT PHYSICAL IF-ID
LINE TYPE
COMMUNICATION DIRECTION
Logical Path ID
INPUT ROUTE ID
OUTPUT ROUTE ID
SYSTEM TYPE
OTHER INFORMATION
PHY-1 GbE Up VLAN-j LSP-m W
PHY-1 GbE Up VLAN-j LSP-n P
PHY-10 10GbE Down LSP-y VLAN-q W
PHY-10 10GbE Down LSP-w VLAN-q P

FIG.13

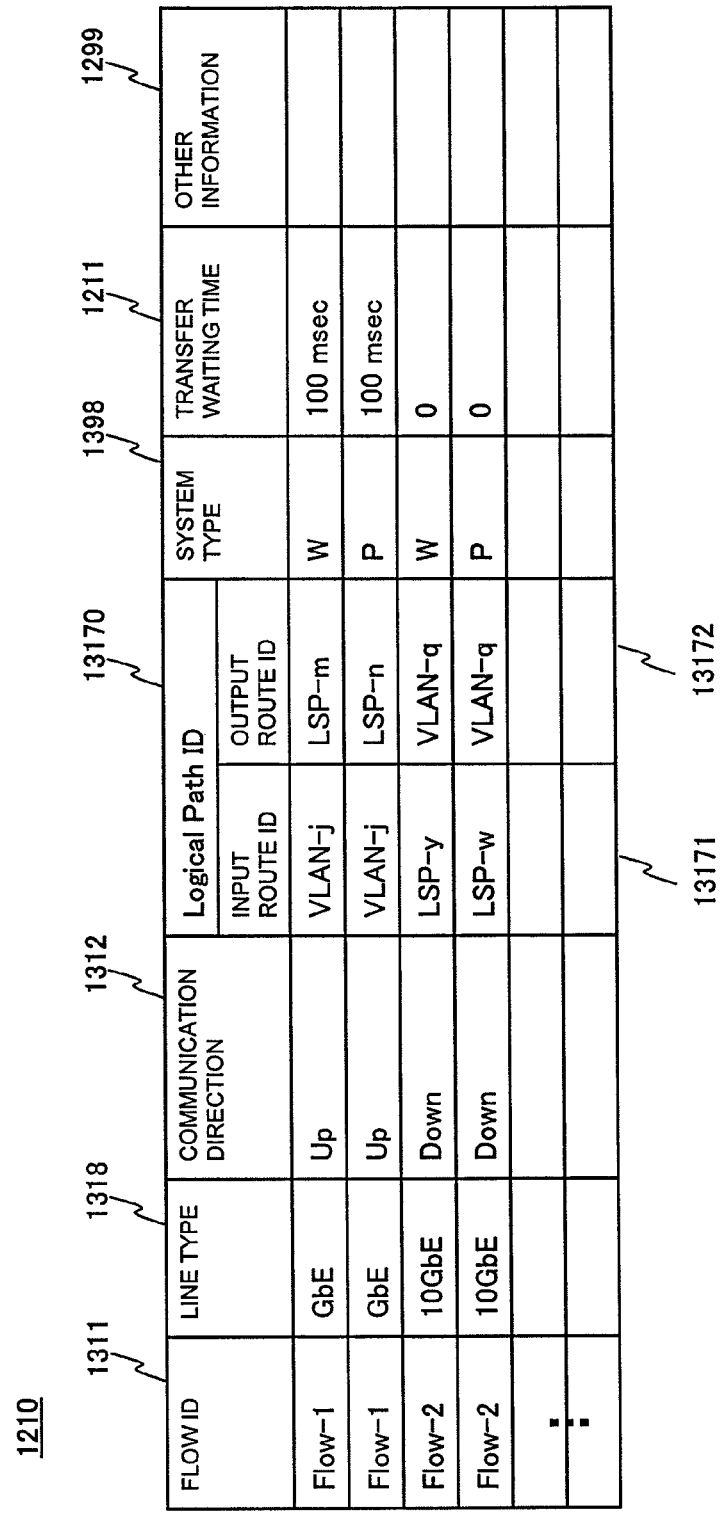

1210
1311
1318
1312
13170
1398
1211
1299
13171
13172
FLOW ID
LINE TYPE
COMMUNICATION DIRECTION
Logical Path ID
INPUT ROUTE ID
OUTPUT ROUTE ID
SYSTEM TYPE
TRANSFER WAITING TIME
OTHER INFORMATION
Flow-1 GbE Up VLAN-j LSP-m W 100 msec
Flow-1 GbE Up VLAN-j LSP-n P 100 msec
Flow-2 10GbE Down LSP-y VLAN-q W 0
Flow-2 10GbE Down LSP-w VLAN-q P 0

FIG.14

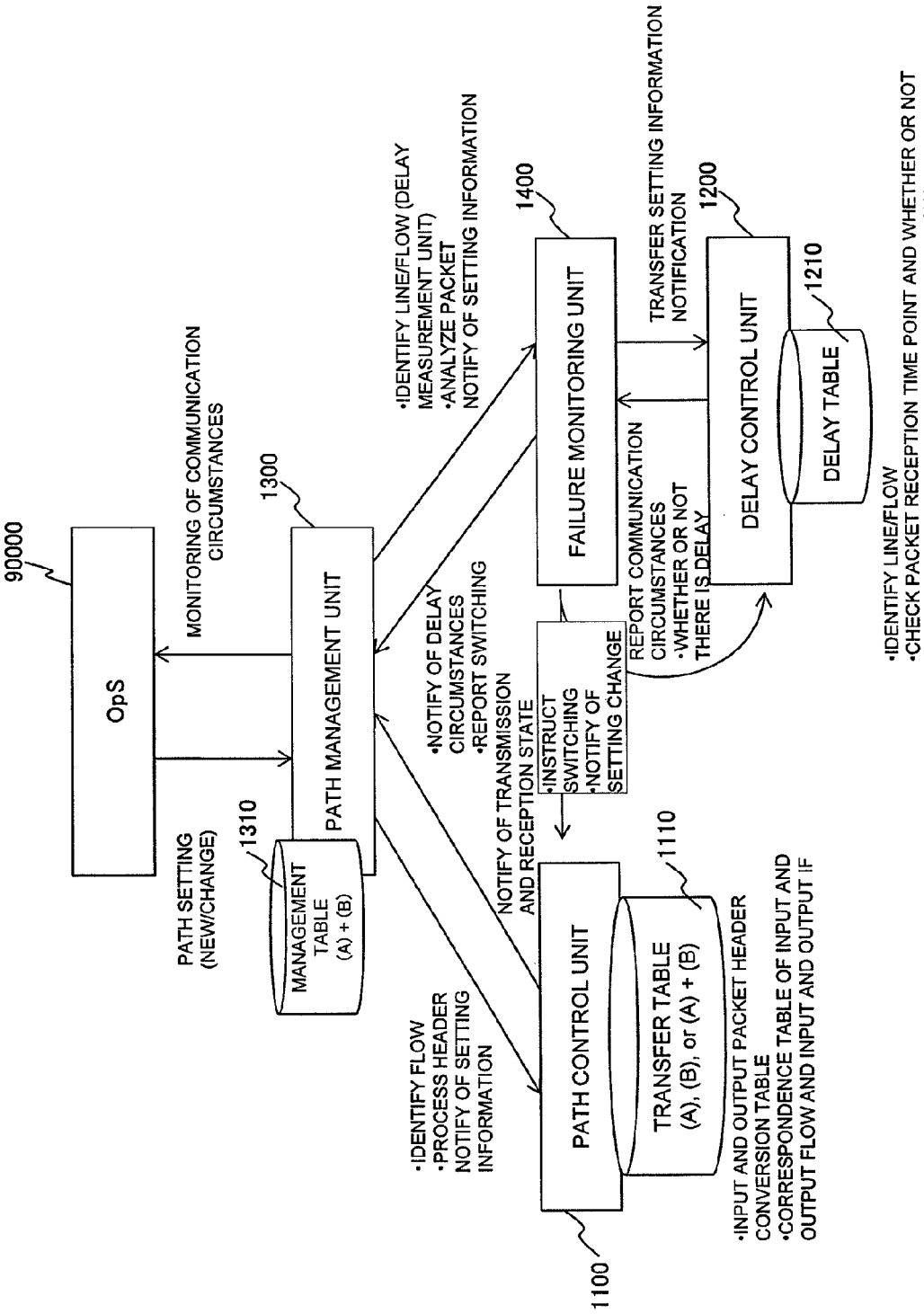

90000
OpS
MONITORING OF COMMUNICATION CIRCUMSTANCES
PATH SETTING (NEW/CHANGE)
1300
PATH MANAGEMENT UNIT
1310
MANAGEMENT TABLE (A) + (B)
•IDENTIFY LINE/FLOW (DELAY MEASUREMENT UNIT)
•ANALYZE PACKET
NOTIFY OF SETTING INFORMATION
1400
FAILURE MONITORING UNIT
TRANSFER SETTING INFORMATION NOTIFICATION
1200
DELAY CONTROL UNIT
1210
DELAY TABLE
•NOTIFY OF DELAY CIRCUMSTANCES
•REPORT SWITCHING
NOTIFY OF TRANSMISSION AND RECEPTION STATE
•INSTRUCT SWITCHING
•NOTIFY OF SETTING CHANGE
REPORT COMMUNICATION CIRCUMSTANCES
•WHETHER OR NOT THERE IS DELAY
•IDENTIFY LINE/FLOW
•CHECK PACKET RECEPTION TIME POINT AND WHETHER OR NOT THERE IS OAM INFORMATION FOR EACH LINE/FLOW
•IDENTIFY FLOW
•PROCESS HEADER
NOTIFY OF SETTING INFORMATION
1100
PATH CONTROL UNIT
1110
TRANSFER TABLE (A), (B), or (A) + (B)
•INPUT AND OUTPUT PACKET HEADER
CONVERSION TABLE
•CORRESPONDENCE TABLE OF INPUT AND OUTPUT FLOW AND INPUT AND OUTPUT IF

FIG.15

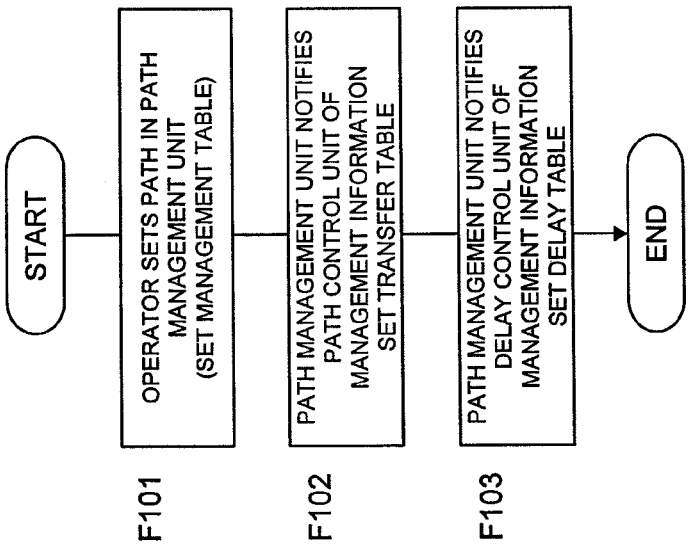

START
OPERATOR SETS PATH IN PATH MANAGEMENT UNIT (SET MANAGEMENT TABLE)
PATH MANAGEMENT UNIT NOTIFIES PATH CONTROL UNIT OF MANAGEMENT INFORMATION SET TRANSFER TABLE
PATH MANAGEMENT UNIT NOTIFIES DELAY CONTROL UNIT OF MANAGEMENT INFORMATION SET DELAY TABLE
END
F101
F102
F103

FIG.16

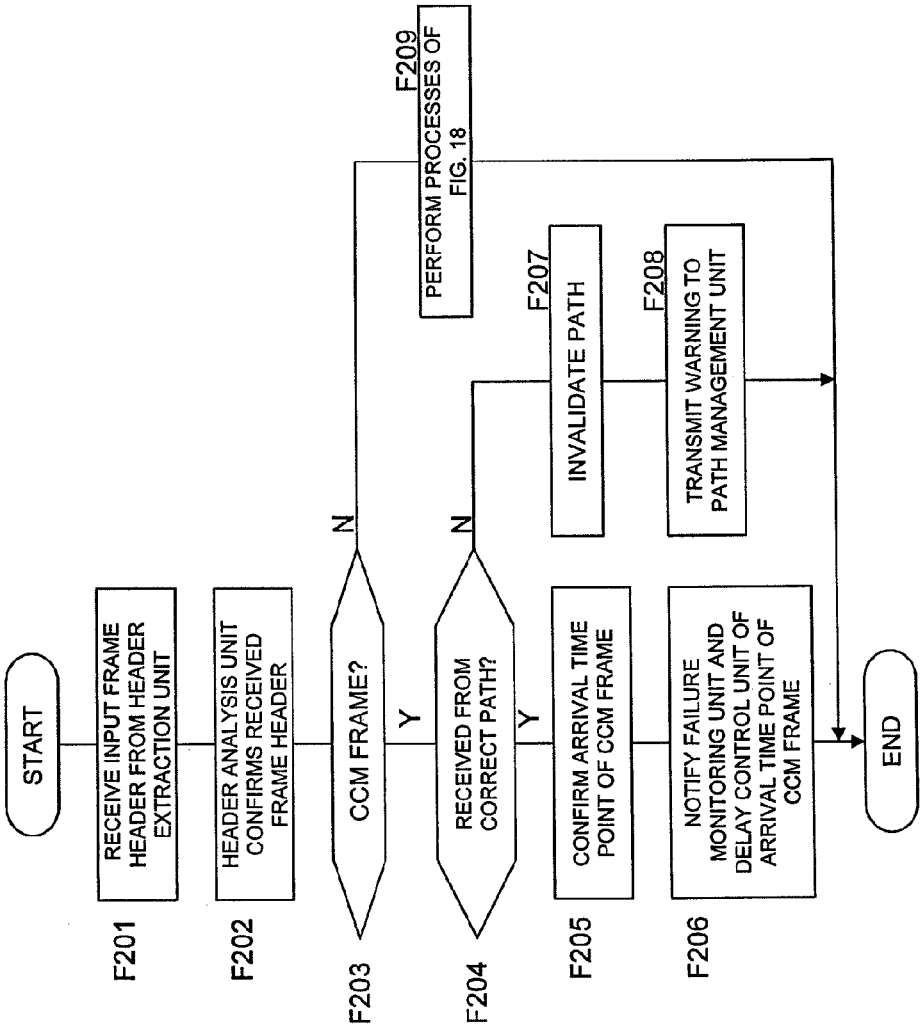

START
RECEIVE INPUT FRAME HEADER FROM HEADER EXTRACTION UNIT
F201
HEADER ANALYSIS UNIT CONFIRMS RECEIVED FRAME HEADER
F202
CCM FRAME?
F203
N
Y
PERFORM PROCESSES OF FIG. 18
F209
RECEIVED FROM CORRECT PATH?
F204
N
Y
INVALIDATE PATH
F207
TRANSMIT WARNING TO PATH MANAGEMENT UNIT
F208
CONFIRM ARRIVAL TIME POINT OF CCM FRAME
F205
NOTIFY FAILURE MONITORING UNIT AND DELAY CONTROL UNIT OF ARRIVAL TIME POINT OF CCM FRAME
F206
END

FIG.17

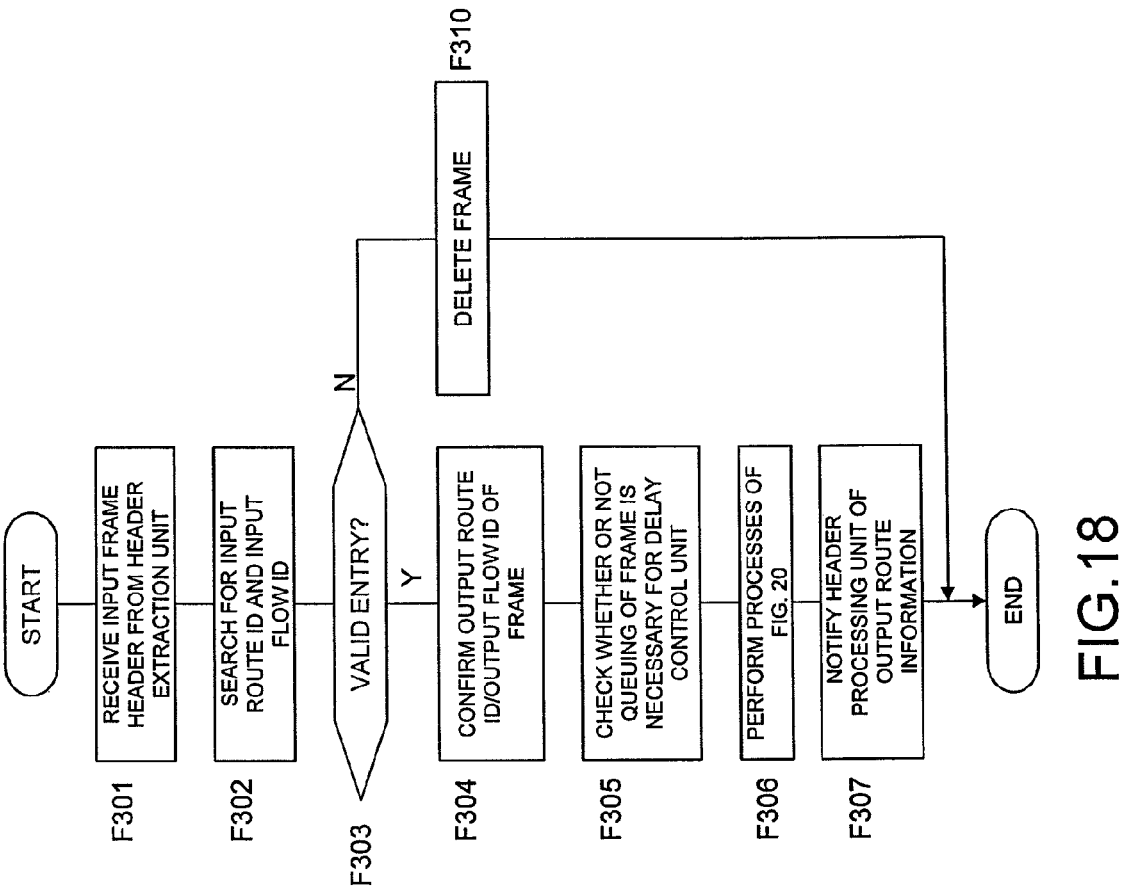

START
RECEIVE INPUT FRAME HEADER FROM HEADER EXTRACTION UNIT
F301
SEARCH FOR INPUT ROUTE ID AND INPUT FLOW ID
F302
VALID ENTRY?
F303
N
Y
DELETE FRAME
F310
CONFIRM OUTPUT ROUTE ID/OUTPUT FLOW ID OF FRAME
F304
CHECK WHETHER OR NOT QUEUING OF FRAME IS NECESSARY FOR DELAY CONTROL UNIT
F305
PERFORM PROCESSES OF FIG. 20
F306
NOTIFY HEADER PROCESSING UNIT OF OUTPUT ROUTE INFORMATION
F307
END

FIG.18

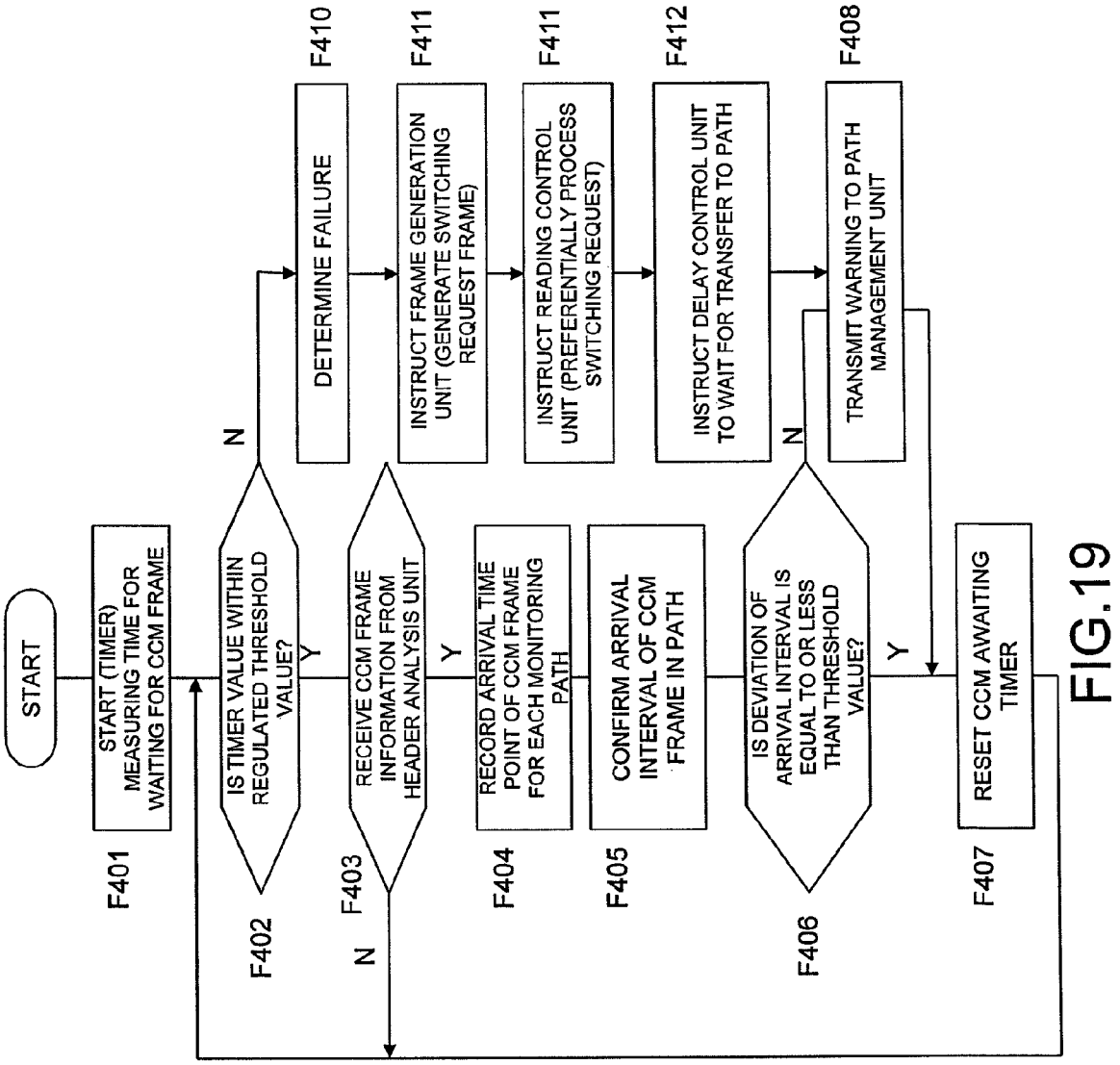

START
START (TIMER) MEASURING TIME FOR WAITING FOR CCM FRAME
F401
IS TIMER VALUE WITHIN REGULATED THRESHOLD VALUE?
F402
N
Y
DETERMINE FAILURE
F410
RECEIVE CCM FRAME INFORMATION FROM HEADER ANALYSIS UNIT
F403
N
Y
INSTRUCT FRAME GENERATION UNIT (GENERATE SWITCHING REQUEST FRAME)
F411
RECORD ARRIVAL TIME POINT OF CCM FRAME FOR EACH MONITORING PATH
F404
INSTRUCT READING CONTROL UNIT (PREFERENTIALLY PROCESS SWITCHING REQUEST)
F411
CONFIRM ARRIVAL INTERVAL OF CCM FRAME IN PATH
F405
INSTRUCT DELAY CONTROL UNIT TO WAIT FOR TRANSFER TO PATH
F412
IS DEVIATION OF ARRIVAL INTERVAL IS EQUAL TO OR LESS THAN THRESHOLD VALUE?
F406
N
Y
TRANSMIT WARNING TO PATH MANAGEMENT UNIT
F408
RESET CCM AWAITING TIMER
F407

FIG.19

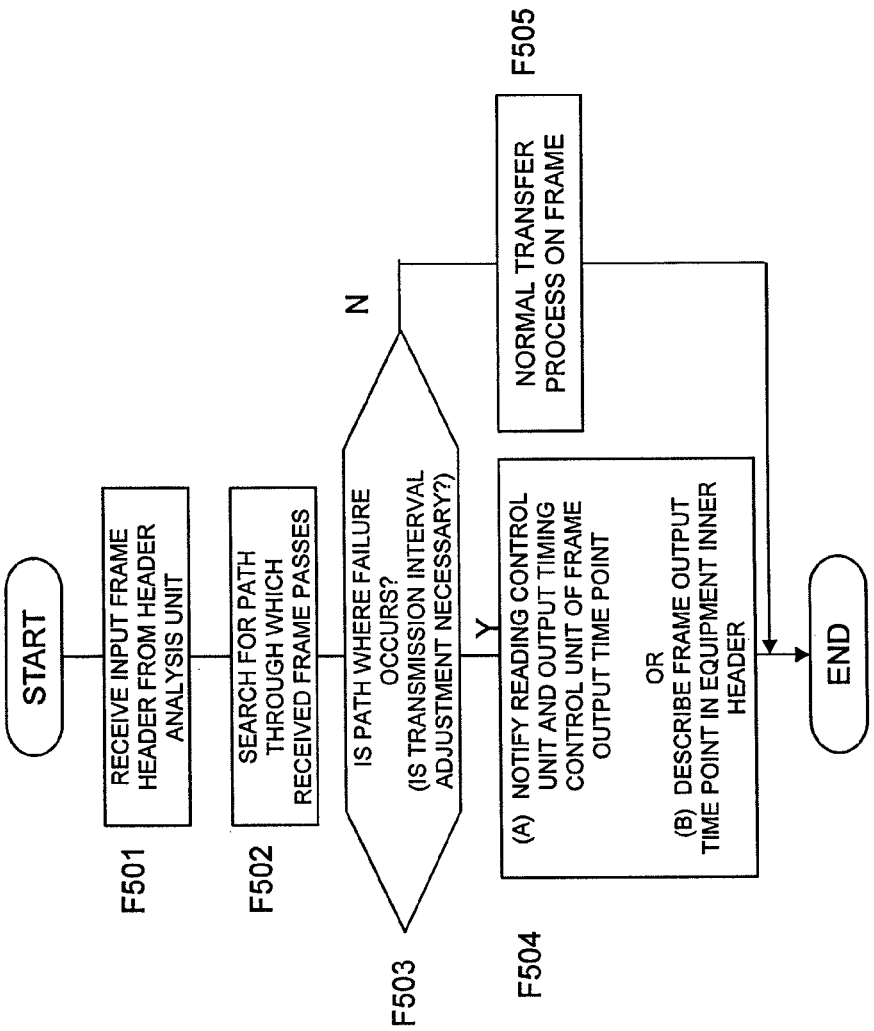

START
RECEIVE INPUT FRAME HEADER FROM HEADER ANALYSIS UNIT
F501
SEARCH FOR PATH THROUGH WHICH RECEIVED FRAME PASSES
F502
IS PATH WHERE FAILURE OCCURS? (IS TRANSMISSION INTERVAL ADJUSTMENT NECESSARY?)
F503
N
Y
NORMAL TRANSFER PROCESS ON FRAME
F505
(A) NOTIFY READING CONTROL UNIT AND OUTPUT TIMING CONTROL UNIT OF FRAME OUTPUT TIME POINT
OR
(B) DESCRIBE FRAME OUTPUT TIME POINT IN EQUIPMENT INNER HEADER
F504
END

FIG.20

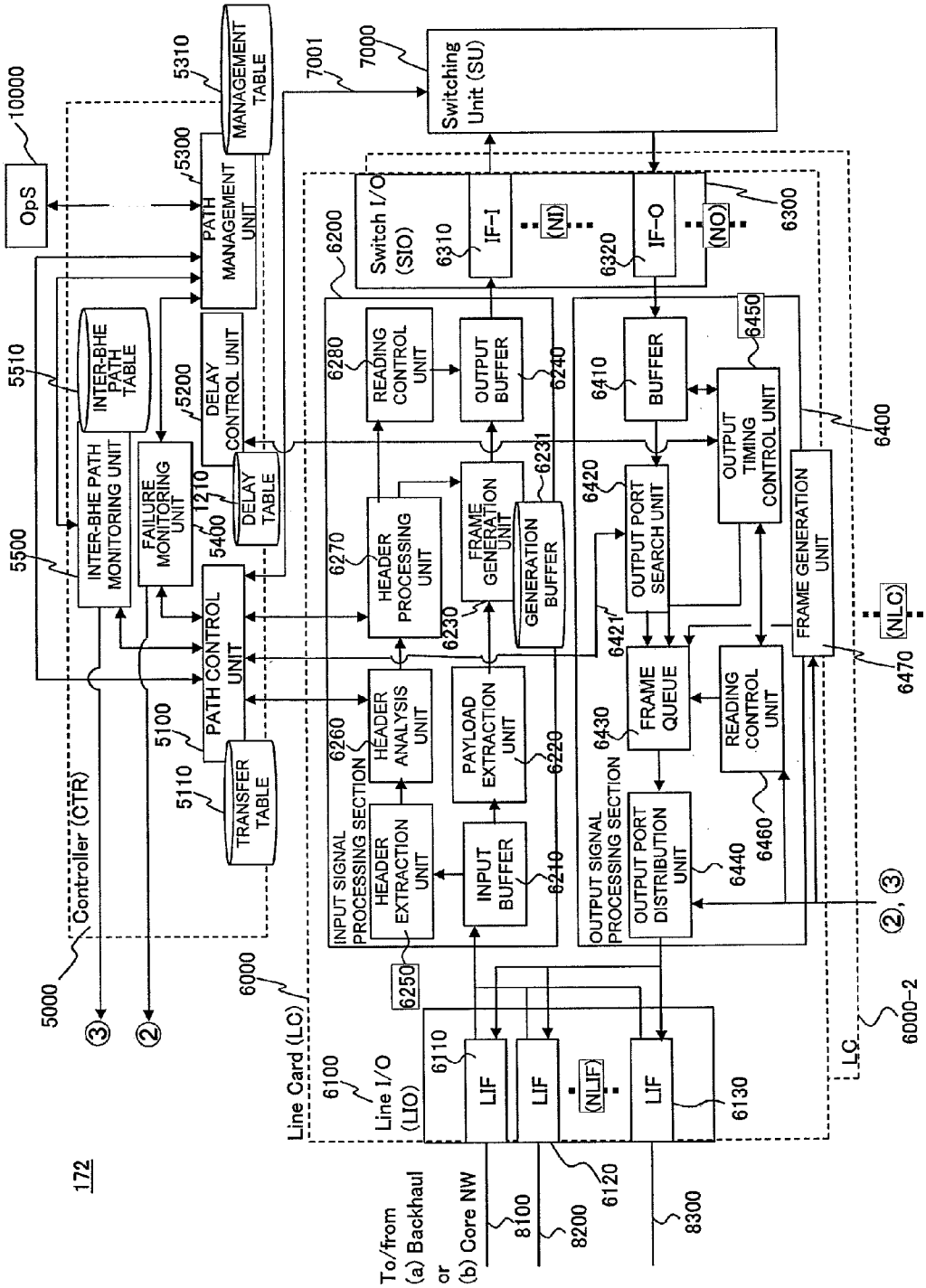

172
Controller (CTR)
5000
10000
OpS
5310
MANAGEMENT TABLE
5300
PATH MANAGEMENT UNIT
5510
INTER-BHE PATH TABLE
INTER-BHE PATH MONITORING UNIT
5200
DELAY CONTROL UNIT
1210
DELAY TABLE
5500
FAILURE MONITORING UNIT
5400
PATH CONTROL UNIT
5100
5110
TRANSFER TABLE
7001
7000
Switching Unit (SU)
6000
Line Card (LC)
6100
Line I/O (LIO)
6200
Switch I/O (SIO)
6310
IF-1
(NI)
6320
IF-O
(NO)
6300
6280
READING CONTROL UNIT
OUTPUT BUFFER
6240
6231
6270
HEADER PROCESSING UNIT
6230
FRAME GENERATION UNIT
GENERATION BUFFER
6260
HEADER ANALYSIS UNIT
6220
PAYLOAD EXTRACTION UNIT
6250
HEADER EXTRACTION UNIT
6210
INPUT BUFFER
INPUT SIGNAL PROCESSING SECTION
6410
BUFFER
6450
6420
OUTPUT PORT SEARCH UNIT
OUTPUT TIMING CONTROL UNIT
6400
6421
6430
FRAME QUEUE
READING CONTROL UNIT
6440
OUTPUT PORT DISTRIBUTION UNIT
6460
OUTPUT SIGNAL PROCESSING SECTION
FRAME GENERATION UNIT
6470
(NLC)
6110
LIF
(NLIF)
6130
6120
LC
6000-2
To/from (a) Backhaul or (b) Core NW
8100
8200
8300
②, ③

FIG.21

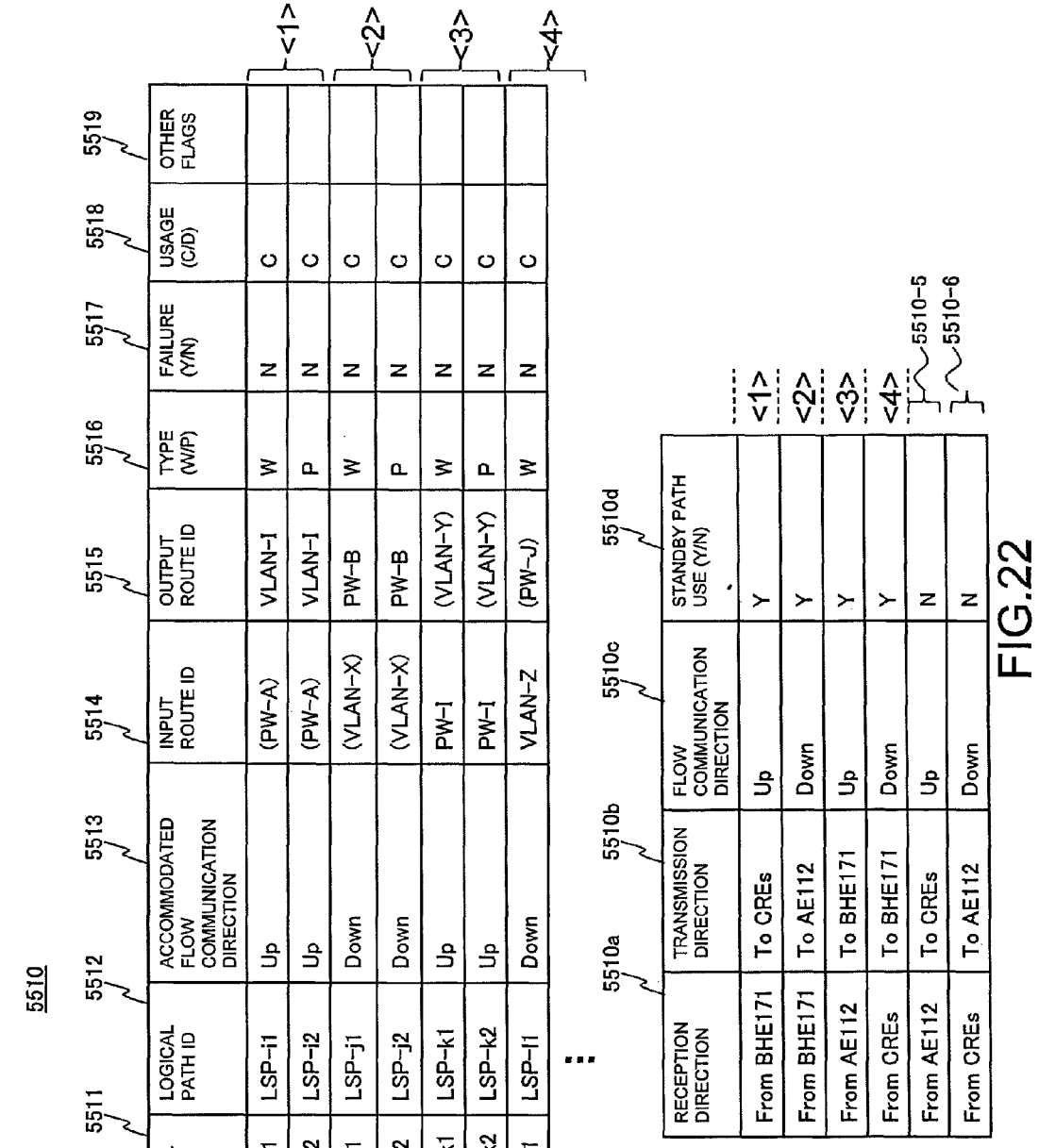

5510
(A)
5511
5512
5513
5514
5515
5516
5517
5518
5519
LOGICAL IF ID
LOGICAL PATH ID
ACCOMMODATED FLOW COMMUNICATION DIRECTION
INPUT ROUTE ID
OUTPUT ROUTE ID
TYPE (W/P)
FAILURE (Y/N)
USAGE (C/D)
OTHER FLAGS
to171-i1 LSP-i1 Up (PW-A) VLAN-I W N C
to171-i2 LSP-i2 Up (PW-A) VLAN-I P N C
to171-j1 LSP-j1 Down (VLAN-X) PW-B W N C
to171-j2 LSP-j2 Down (VLAN-X) PW-B P N C
to171-k1 LSP-k1 Up PW-I (VLAN-Y) W N C
to171-k2 LSP-k2 Up PW-I (VLAN-Y) P N C
to171-l1 LSP-l1 Down VLAN-Z (PW-J) W N C
<1>
<2>
<3>
<4>
(B)
5510a
5510b
5510c
5510d
RECEPTION DIRECTION
TRANSMISSION DIRECTION
FLOW COMMUNICATION DIRECTION
STANDBY PATH USE (Y/N)
From BHE171 To CREs Up Y
From BHE171 To AE112 Down Y
From AE112 To BHE171 Up Y
From CREs To BHE171 Down Y
From AE112 To CREs Up N
From CREs To AE112 Down N
<1>
<2>
<3>
<4>
5510-5
5510-6

FIG.22

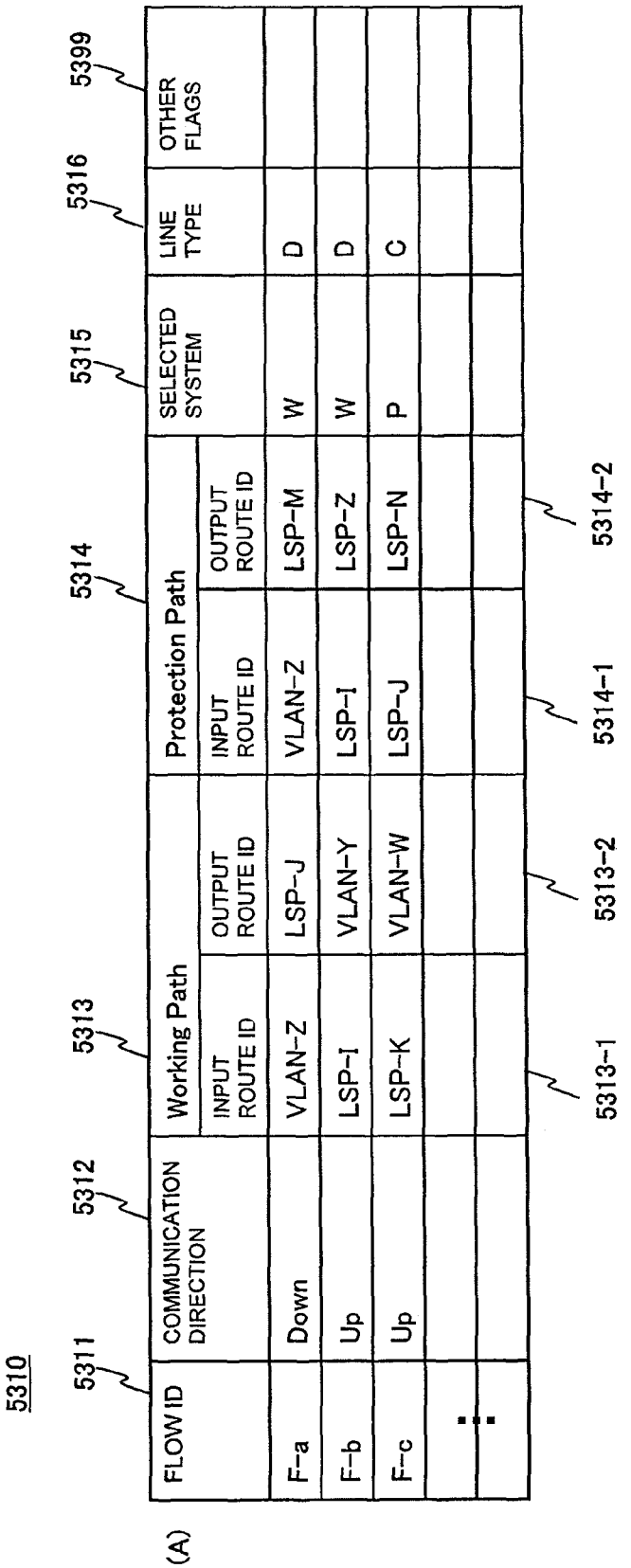

5310
(A)
5311
5312
5313
5314
5315
5316
5399
FLOW ID
COMMUNICATION DIRECTION
Working Path
INPUT ROUTE ID
OUTPUT ROUTE ID
Protection Path
INPUT ROUTE ID
OUTPUT ROUTE ID
SELECTED SYSTEM
LINE TYPE
OTHER FLAGS
F-a
Down
VLAN-Z
LSP-J
VLAN-Z
LSP-M
W
D
F-b
Up
LSP-I
VLAN-Y
LSP-I
LSP-Z
W
D
F-c
Up
LSP-K
VLAN-W
LSP-J
LSP-N
P
C
5313-1
5313-2
5314-1
5314-2

FIG.23

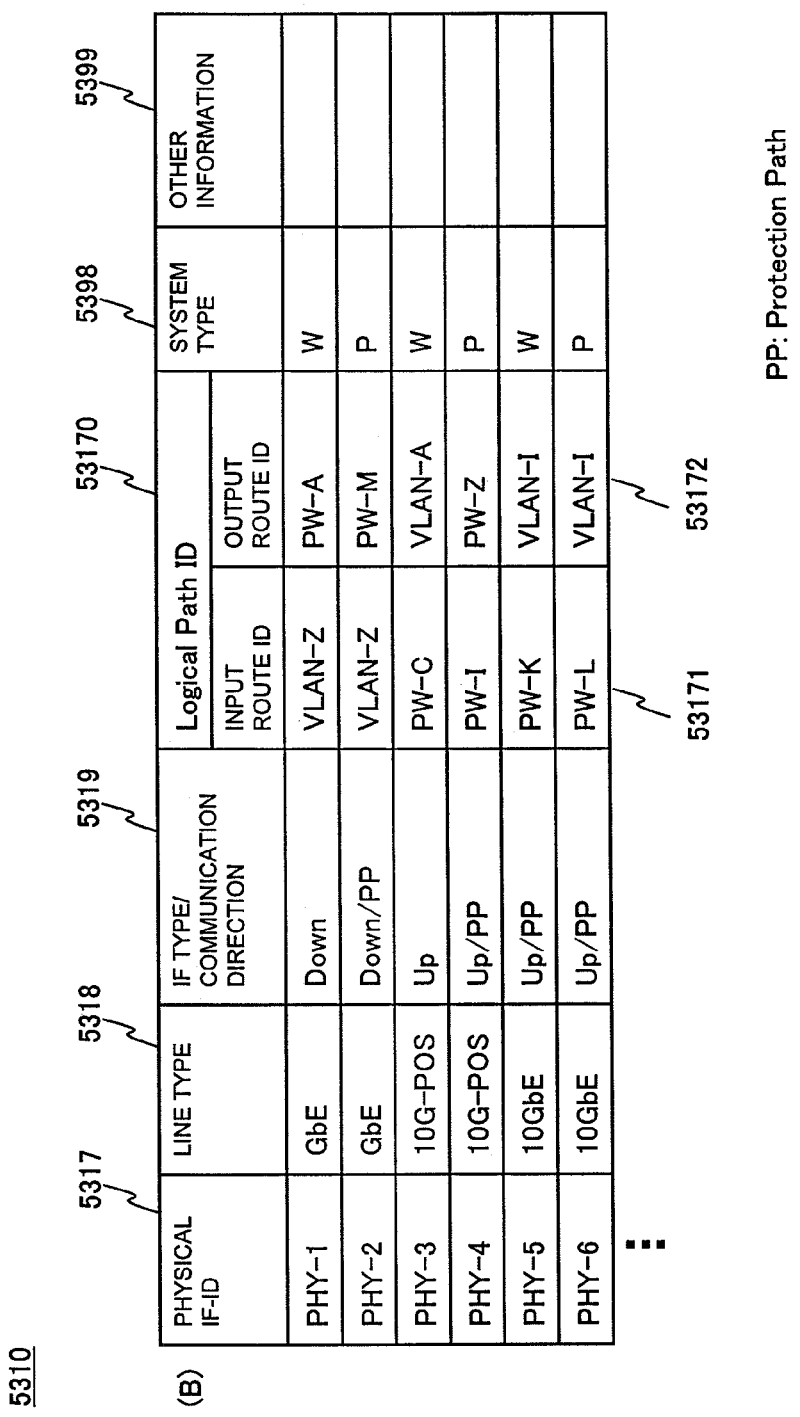

5310
(B)
5317
5318
5319
53170
5398
5399
PHYSICAL IF-ID
LINE TYPE
IF TYPE/ COMMUNICATION DIRECTION
Logical Path ID
INPUT ROUTE ID
OUTPUT ROUTE ID
SYSTEM TYPE
OTHER INFORMATION
PHY-1 GbE Down VLAN-Z PW-A W
PHY-2 GbE Down/PP VLAN-Z PW-M P
PHY-3 10G-POS Up PW-C VLAN-A W
PHY-4 10G-POS Up/PP PW-I PW-Z P
PHY-5 10GbE Up/PP PW-K VLAN-I W
PHY-6 10GbE Up/PP PW-L VLAN-I P
53171
53172
PP: Protection Path

FIG.24

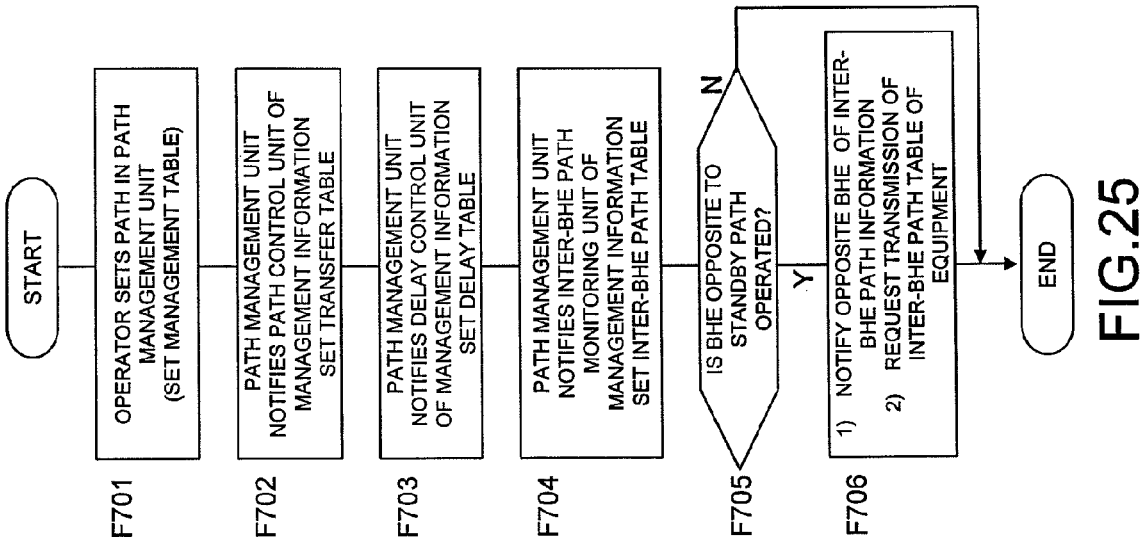

START
F701
OPERATOR SETS PATH IN PATH MANAGEMENT UNIT (SET MANAGEMENT TABLE)
F702
PATH MANAGEMENT UNIT NOTIFIES PATH CONTROL UNIT OF MANAGEMENT INFORMATION SET TRANSFER TABLE
F703
PATH MANAGEMENT UNIT NOTIFIES DELAY CONTROL UNIT OF MANAGEMENT INFORMATION SET DELAY TABLE
F704
PATH MANAGEMENT UNIT NOTIFIES INTER-BHE PATH MONITORING UNIT OF MANAGEMENT INFORMATION SET INTER-BHE PATH TABLE
F705
IS BHE OPPOSITE TO STANDBY PATH OPERATED?
N
Y
F706
1) NOTIFY OPPOSITE BHE OF INTER-BHE PATH INFORMATION
2) REQUEST TRANSMISSION OF INTER-BHE PATH TABLE OF EQUIPMENT
END

FIG.25

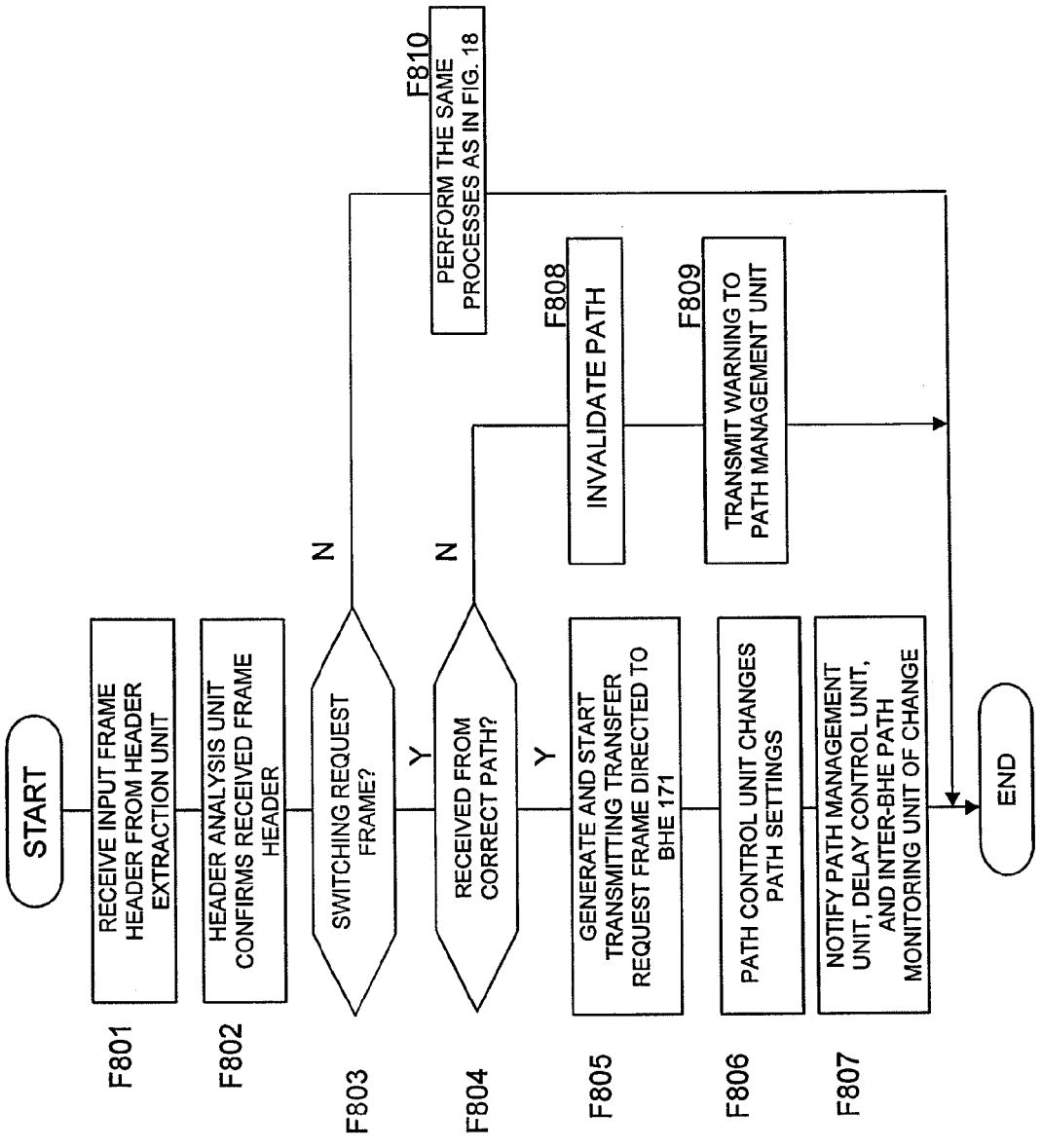

START
RECEIVE INPUT FRAME HEADER FROM HEADER EXTRACTION UNIT
F801
HEADER ANALYSIS UNIT CONFIRMS RECEIVED FRAME HEADER
F802
SWITCHING REQUEST FRAME?
F803
N
Y
PERFORM THE SAME PROCESSES AS IN FIG. 18
F810
RECEIVED FROM CORRECT PATH?
F804
N
Y
INVALIDATE PATH
F808
TRANSMIT WARNING TO PATH MANAGEMENT UNIT
F809
GENERATE AND START TRANSMITTING TRANSFER REQUEST FRAME DIRECTED TO BHE 171
F805
PATH CONTROL UNIT CHANGES PATH SETTINGS
F806
NOTIFY PATH MANAGEMENT UNIT, DELAY CONTROL UNIT, AND INTER-BHE PATH MONITORING UNIT OF CHANGE
F807
END

FIG.26

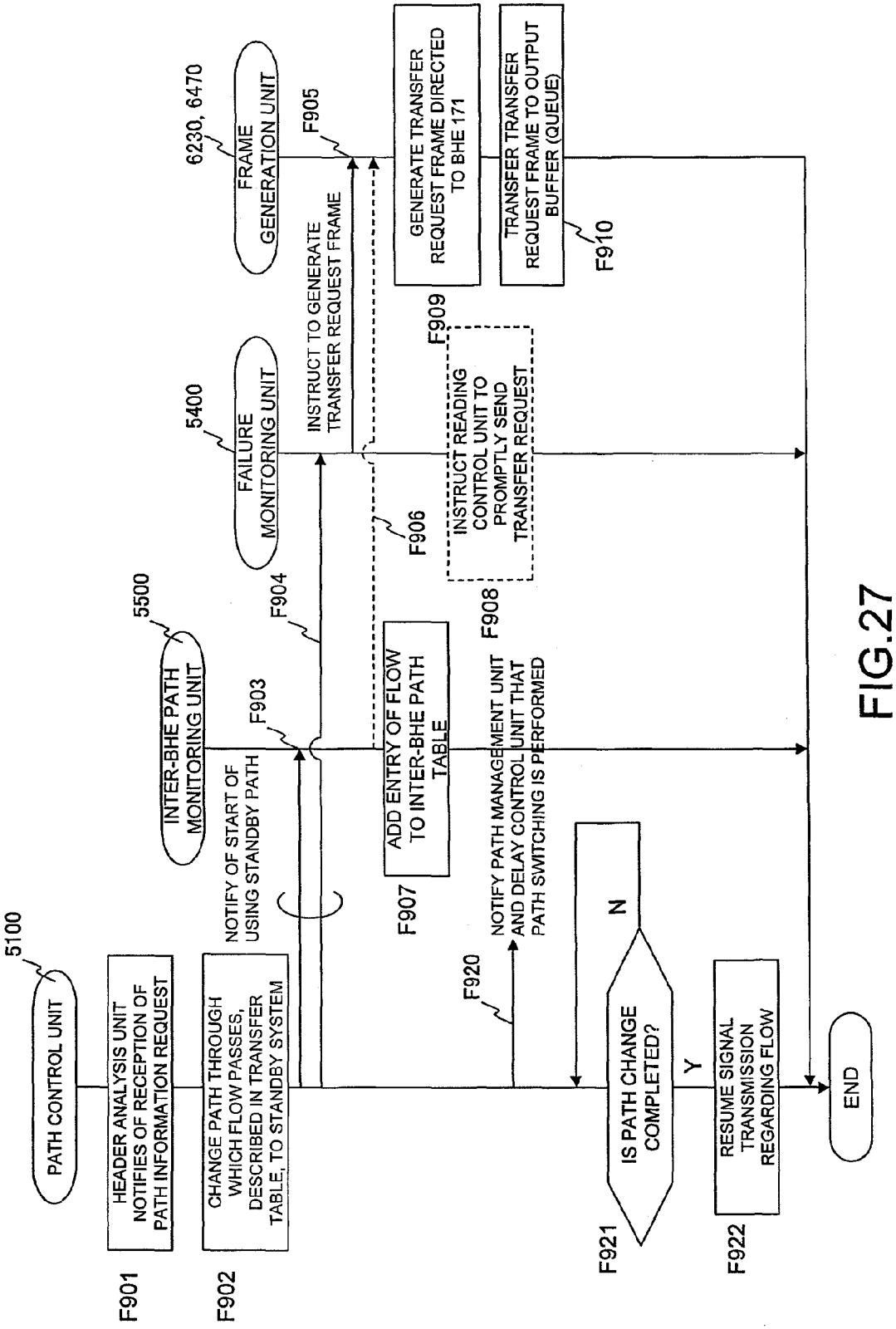

5100
PATH CONTROL UNIT
HEADER ANALYSIS UNIT NOTIFIES OF RECEPTION OF PATH INFORMATION REQUEST
F901
CHANGE PATH THROUGH WHICH FLOW PASSES, DESCRIBED IN TRANSFER TABLE, TO STANDBY SYSTEM
F902
NOTIFY OF START OF USING STANDBY PATH
5500
INTER-BHE PATH MONITORING UNIT
F903
F904
5400
FAILURE MONITORING UNIT
INSTRUCT TO GENERATE TRANSFER REQUEST FRAME
6230, 6470
FRAME GENERATION UNIT
F905
F906
ADD ENTRY OF FLOW TO INTER-BHE PATH TABLE
F907
F908
INSTRUCT READING CONTROL UNIT TO PROMPTLY SEND TRANSFER REQUEST
F909
GENERATE TRANSFER REQUEST FRAME DIRECTED TO BHE 171
TRANSFER TRANSFER REQUEST FRAME TO OUTPUT BUFFER (QUEUE)
F910
NOTIFY PATH MANAGEMENT UNIT AND DELAY CONTROL UNIT THAT PATH SWITCHING IS PERFORMED
F920
IS PATH CHANGE COMPLETED?
N
Y
F921
RESUME SIGNAL TRANSMISSION REGARDING FLOW
F922
END

FIG.27

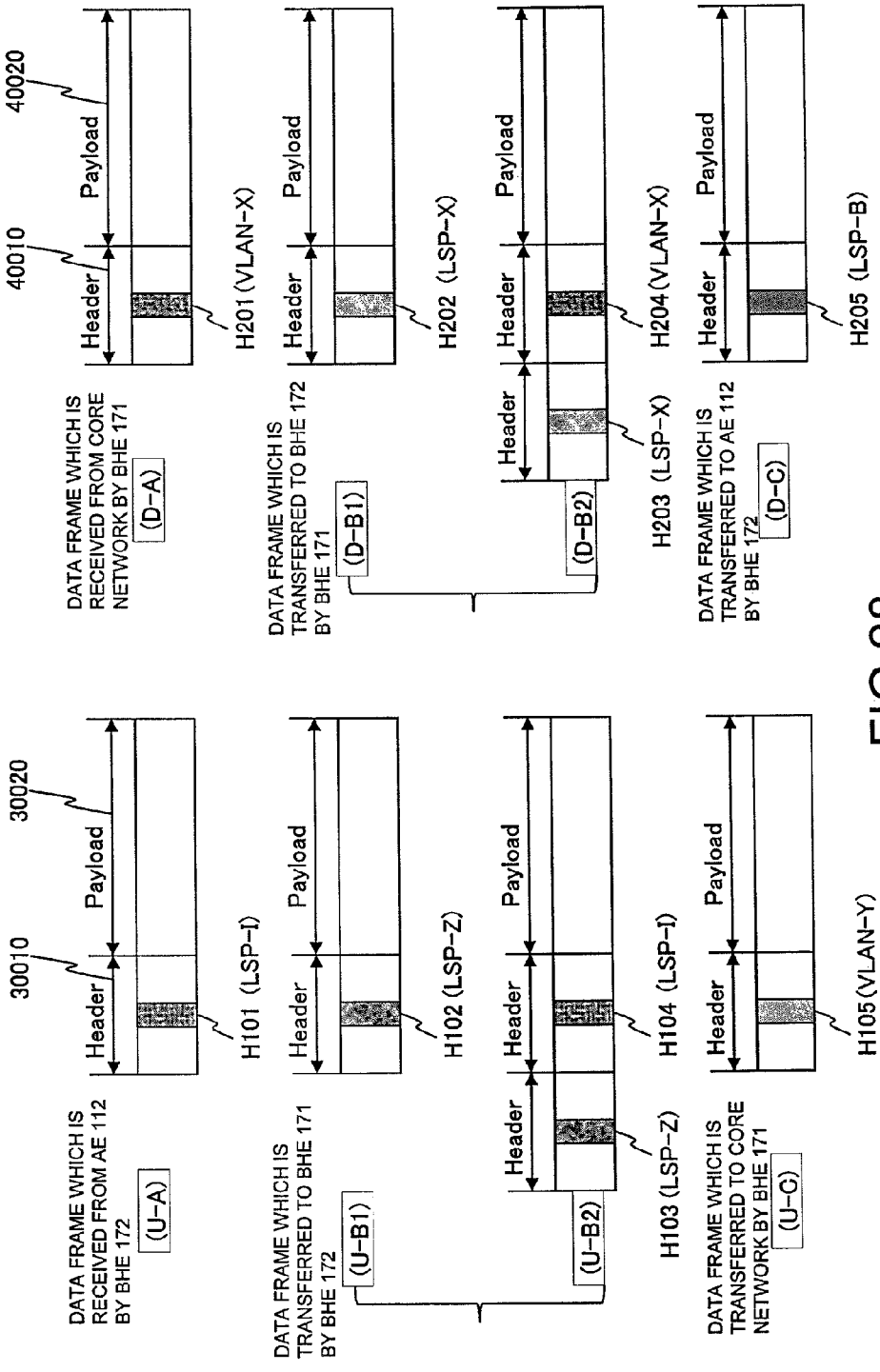

40020
40010
Payload
Header
H201 (VLAN-X)
DATA FRAME WHICH IS RECEIVED FROM CORE NETWORK BY BHE 171
(D-A)
H202 (LSP-X)
DATA FRAME WHICH IS TRANSFERRED TO BHE 172 BY BHE 171
(D-B1)
H203 (LSP-X)
(D-B2)
H204 (VLAN-X)
DATA FRAME WHICH IS TRANSFERRED TO AE 112 BY BHE 172
(D-C)
H205 (LSP-B)
30020
30010
H101 (LSP-1)
DATA FRAME WHICH IS RECEIVED FROM AE 112 BY BHE 172
(U-A)
H102 (LSP-Z)
DATA FRAME WHICH IS TRANSFERRED TO BHE 171 BY BHE 172
(U-B1)
H103 (LSP-Z)
(U-B2)
H104 (LSP-1)
DATA FRAME WHICH IS TRANSFERRED TO CORE NETWORK BY BHE 171
(U-C)
H105 (VLAN-Y)

FIG.28

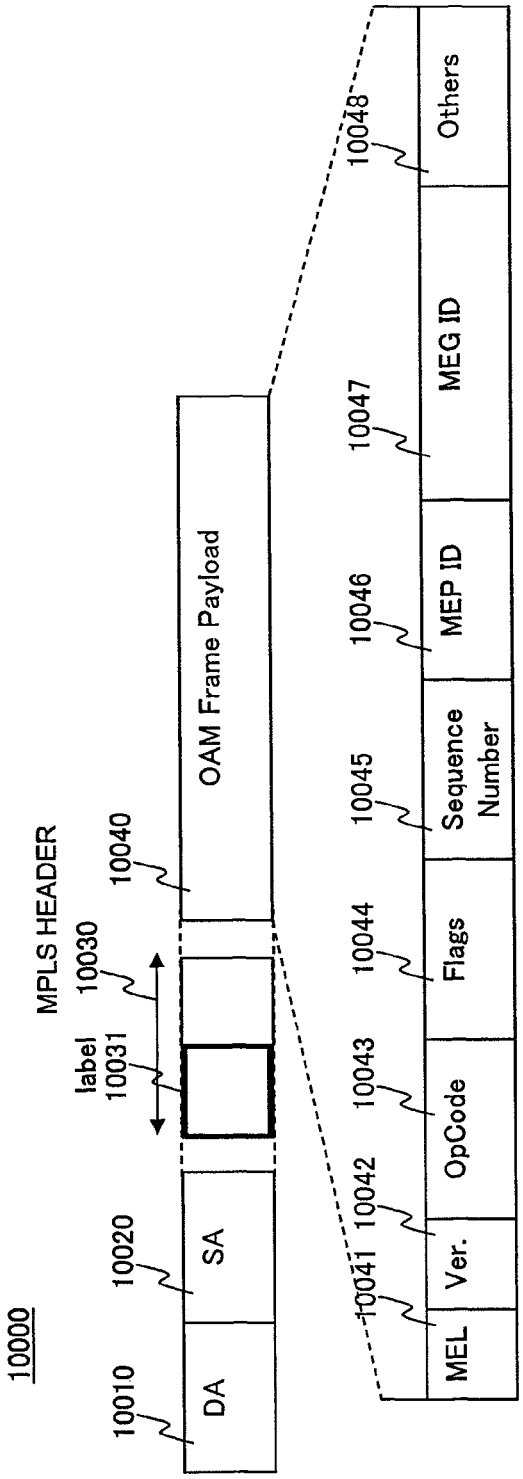

10000
10010
DA
10020
SA
MPLS HEADER
label
10030
10031
10040
OAM Frame Payload
10041
MEL
Ver.
10042
OpCode
10043
Flags
10044
Sequence Number
10045
MEP ID
10046
MEG ID
10047
Others
10048

FIG.29

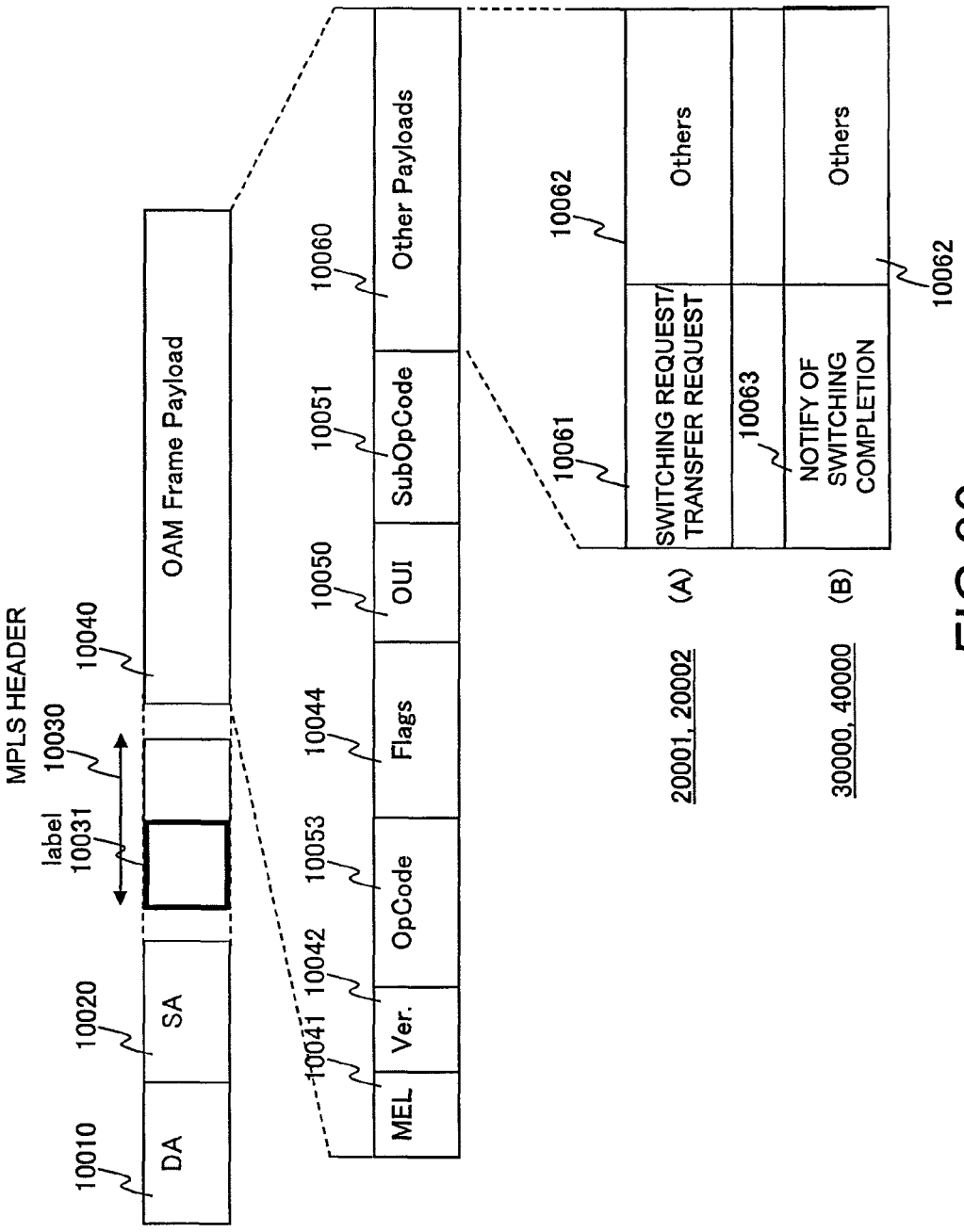
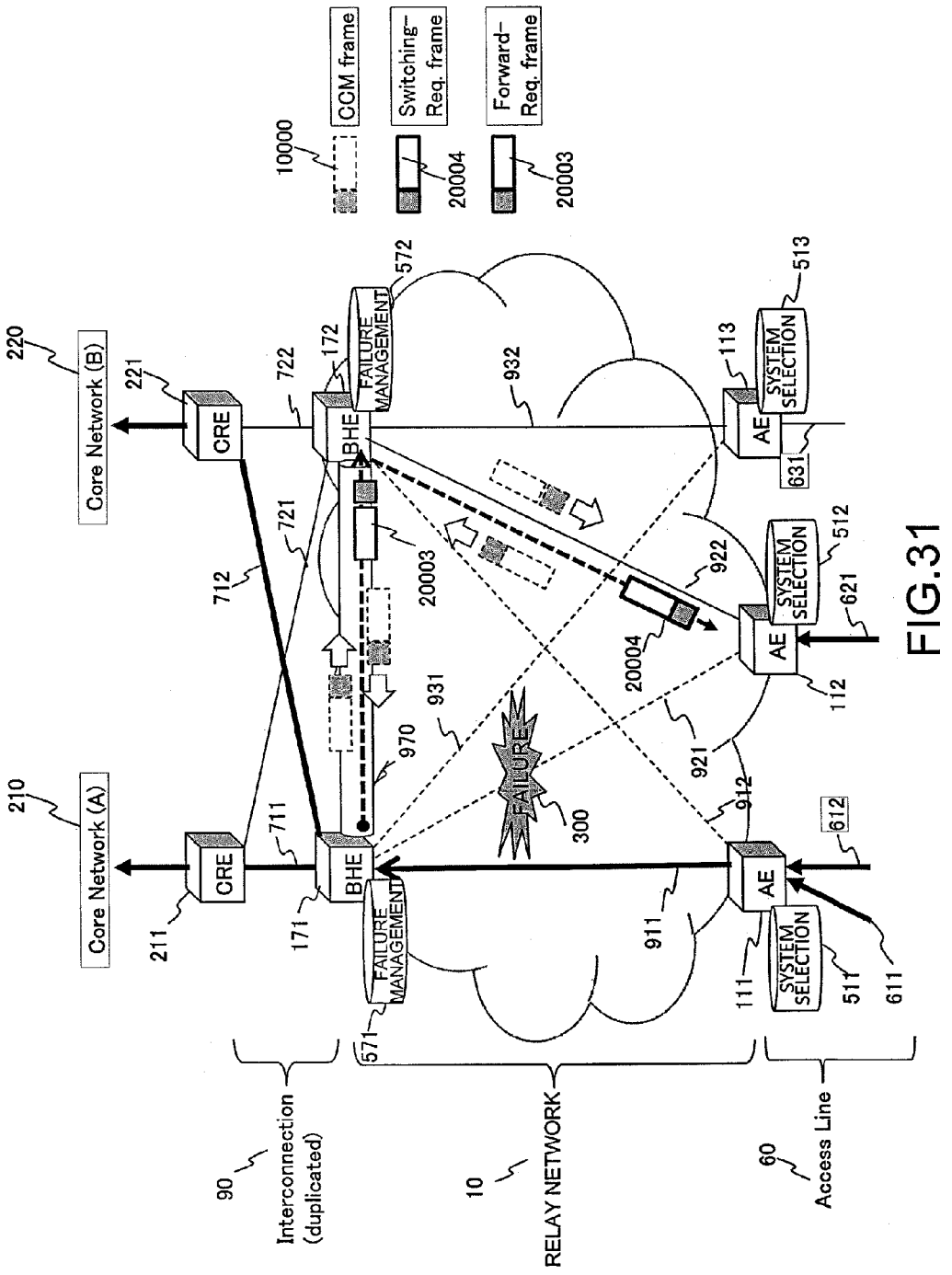

DA
SA
MPLS HEADER
label
OAM Frame Payload
MEL
Ver.
OpCode
Flags
OUI
SubOpCode
Other Payloads
10010
10020
10030
10031
10040
10041
10042
10044
10050
10051
10053
10060
10061
10062
10063
SWITCHING REQUEST/ TRANSFER REQUEST
NOTIFY OF SWITCHING COMPLETION
Others
Others
(A)
(B)
20001, 20002
30000, 40000

FIG.30



10000
CCM frame
Switching-Req. frame
20004
Forward-Req. frame
20003
Core Network (B)
220
221
CRE
722
172
BHE
FAILURE MANAGEMENT
572
932
113
AE
SYSTEM SELECTION
513
631
712
721
20003
922
20004
512
621
112
931
970
921
912
FAILURE
300
Core Network (A)
210
211
711
171
571
911
111
511
611
612
90
Interconnection (duplicated)
10
RELAY NETWORK
60
Access Line

FIG.31

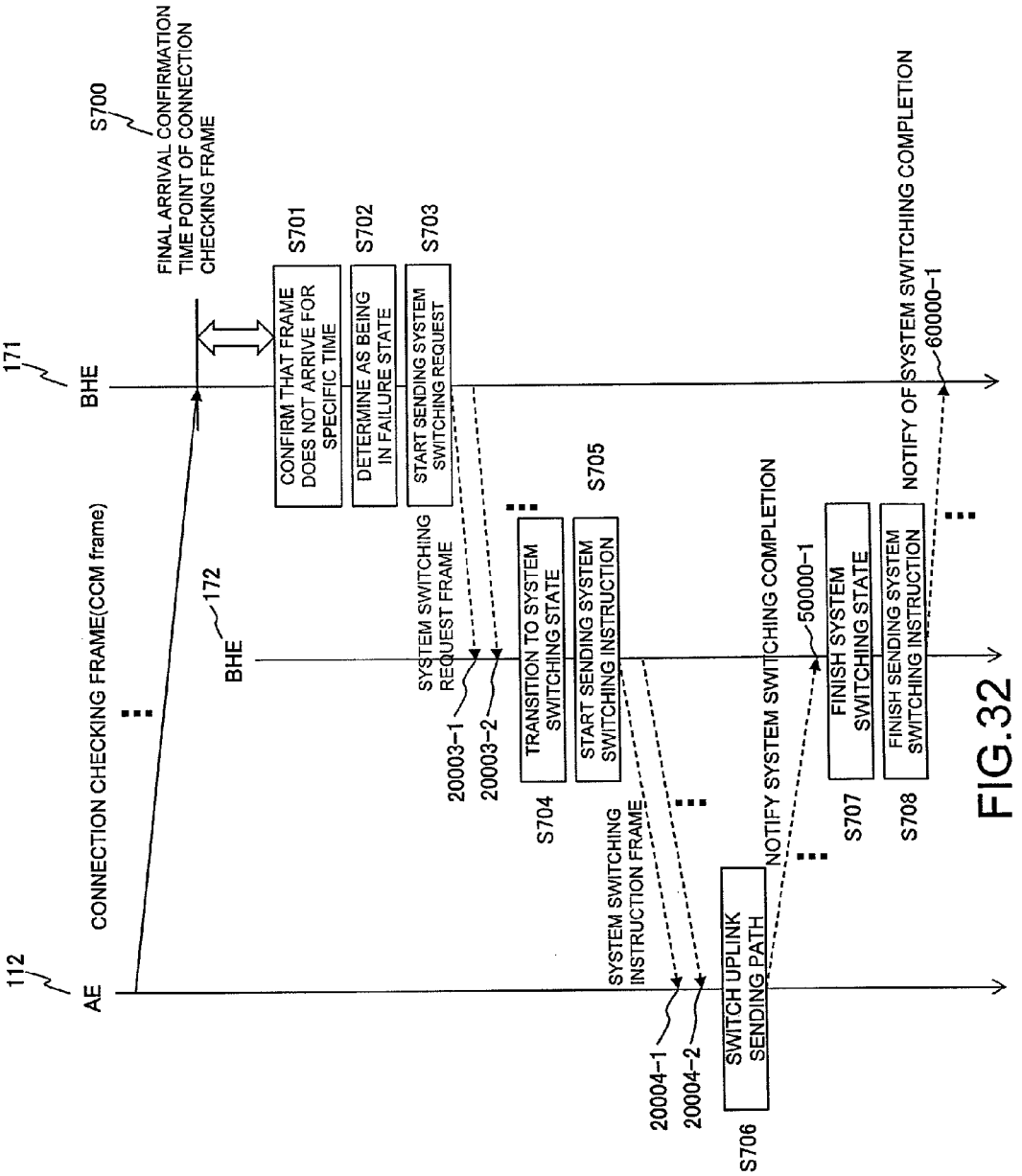

112
AE
CONNECTION CHECKING FRAME(CCM frame)
171
BHE
172
BHE
S700
FINAL ARRIVAL CONFIRMATION TIME POINT OF CONNECTION CHECKING FRAME
S701
CONFIRM THAT FRAME DOES NOT ARRIVE FOR SPECIFIC TIME
S702
DETERMINE AS BEING IN FAILURE STATE
S703
START SENDING SYSTEM SWITCHING REQUEST
SYSTEM SWITCHING REQUEST FRAME
20003-1
20003-2
S704
TRANSITION TO SYSTEM SWITCHING STATE
S705
START SENDING SYSTEM SWITCHING INSTRUCTION
SYSTEM SWITCHING INSTRUCTION FRAME
20004-1
20004-2
S706
SWITCH UPLINK SENDING PATH
NOTIFY SYSTEM SWITCHING COMPLETION
50000-1
S707
FINISH SYSTEM SWITCHING STATE
S708
FINISH SENDING SYSTEM SWITCHING INSTRUCTION
NOTIFY OF SYSTEM SWITCHING COMPLETION
60000-1

FIG.32

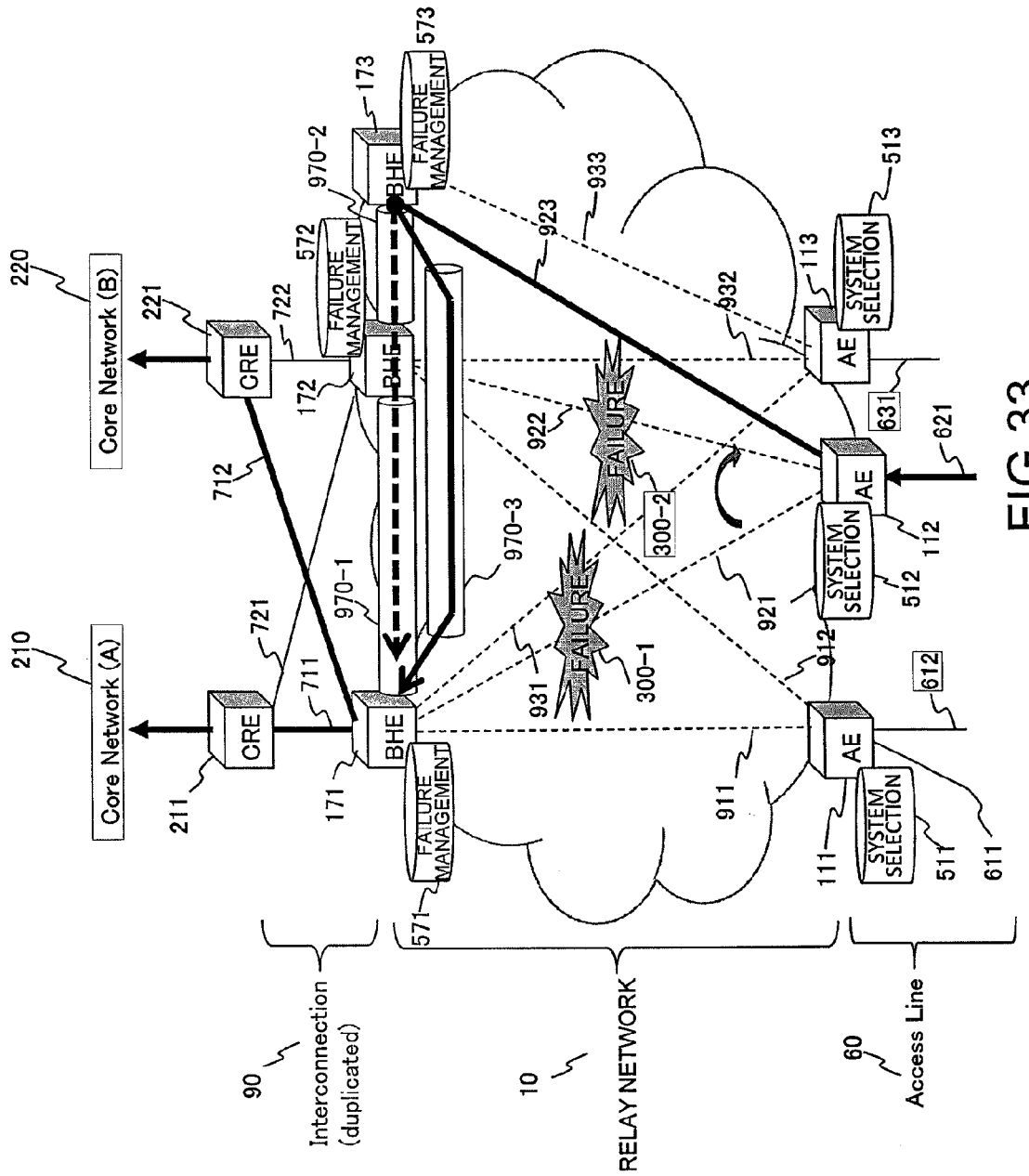

Core Network (A)
Core Network (B)
CRE
CRE
BHE
BHE
BHE
FAILURE MANAGEMENT
FAILURE MANAGEMENT
FAILURE MANAGEMENT
FAILURE
FAILURE
AE
AE
AE
SYSTEM SELECTION
SYSTEM SELECTION
SYSTEM SELECTION
210
220
211
221
722
721
711
712
171
172
173
571
572
573
970-1
970-2
970-3
931
932
933
922
923
911
912
921
922
300-1
300-2
111
112
113
511
512
513
611
612
621
631
90
Interconnection (duplicated)
10
RELAY NETWORK
60
Access Line

FIG.33

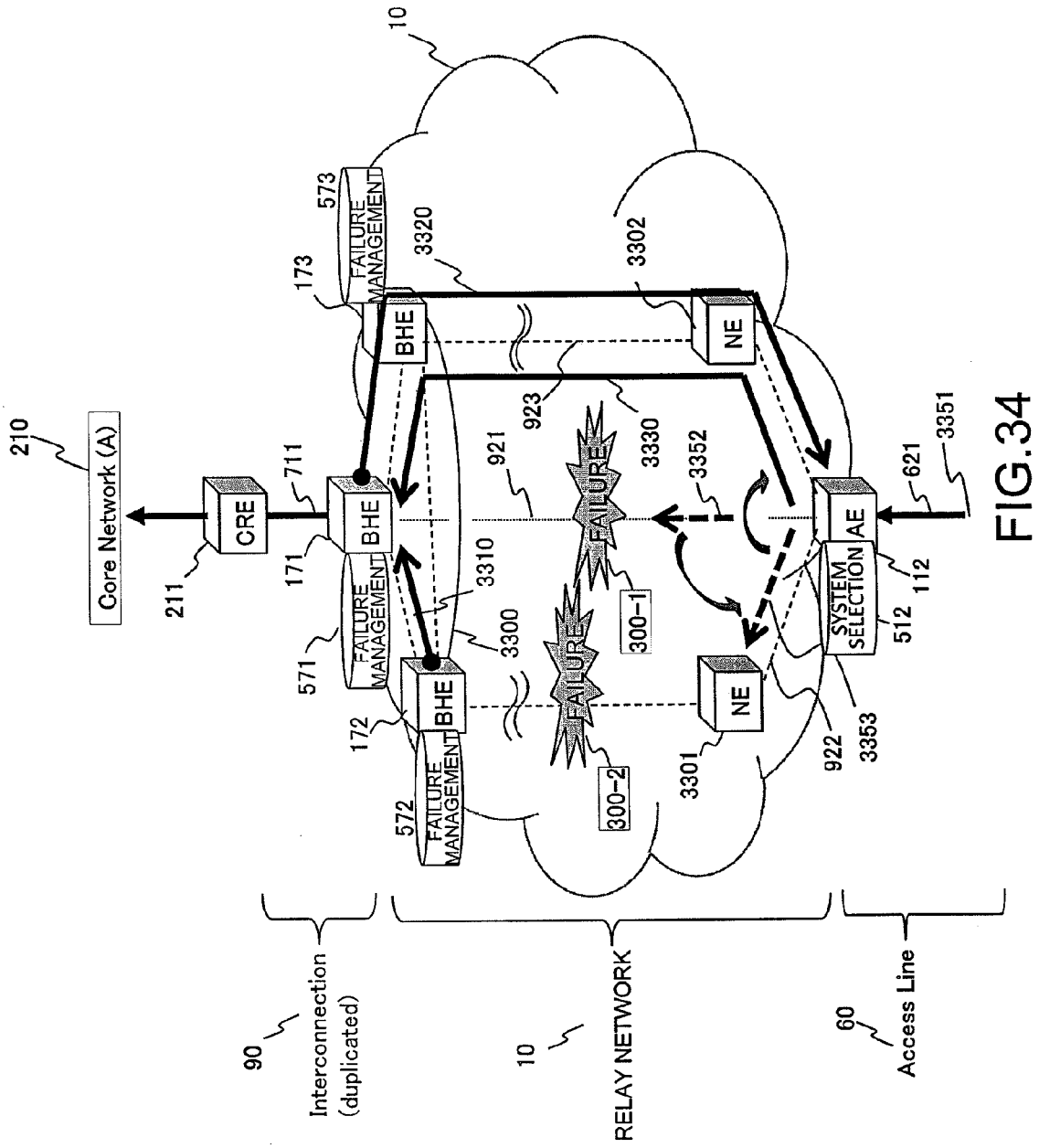

Core Network (A)
210
CRE
211
711
BHE
171
FAILURE MANAGEMENT
571
BHE
172
FAILURE MANAGEMENT
572
BHE
173
FAILURE MANAGEMENT
573
10
3320
3302
NE
923
3330
921
FAILURE
300-1
FAILURE
300-2
3310
3300
3352
NE
3301
922
3353
AE
SYSTEM SELECTION
512
112
621
3351
90
Interconnection (duplicated)
10
RELAY NETWORK
60
Access Line

FIG.34

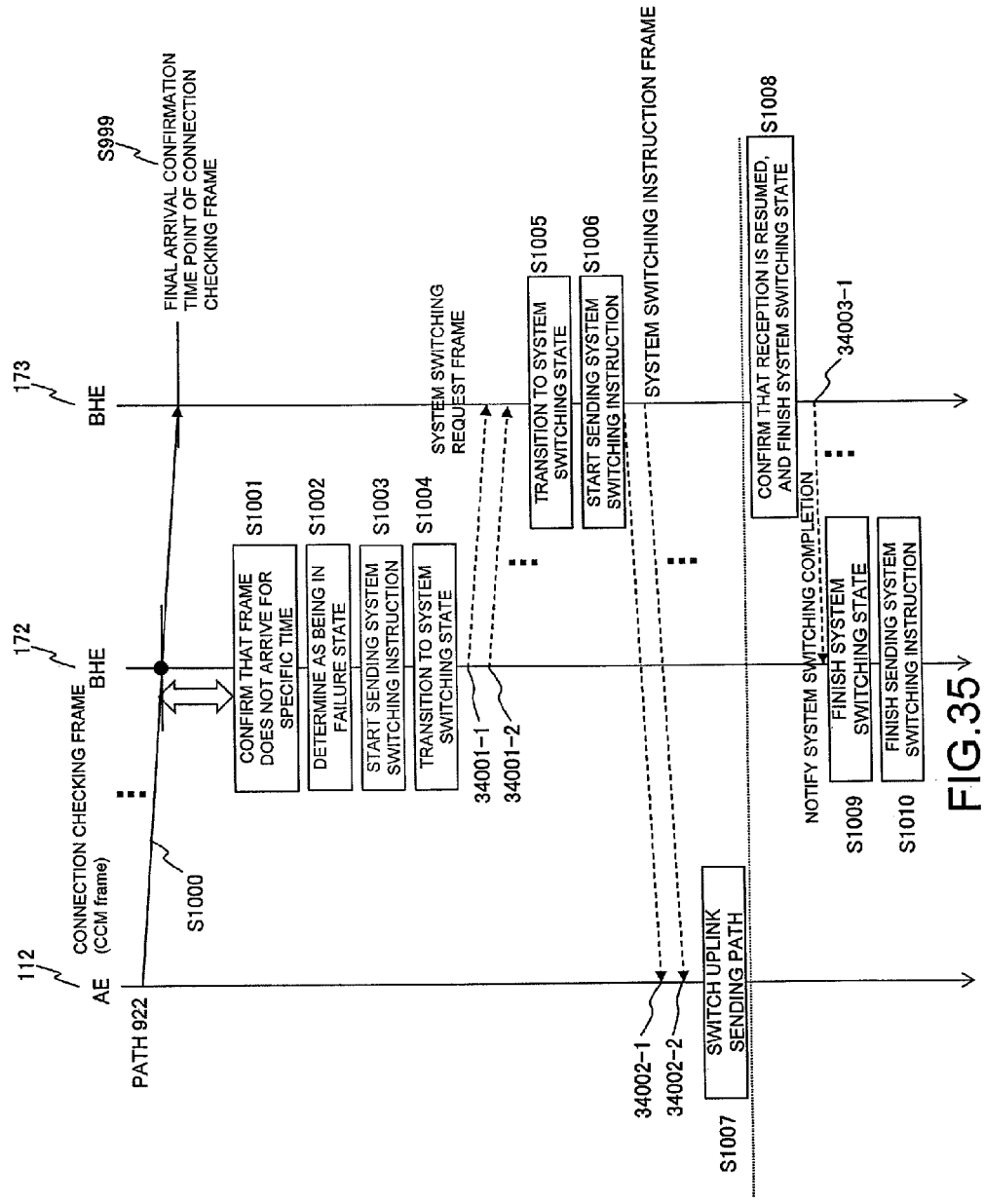

112
AE
CONNECTION CHECKING FRAME (CCM frame)
PATH 922
S1000
172
BHE
173
BHE
S999
FINAL ARRIVAL CONFIRMATION TIME POINT OF CONNECTION CHECKING FRAME
S1001
CONFIRM THAT FRAME DOES NOT ARRIVE FOR SPECIFIC TIME
S1002
DETERMINE AS BEING IN FAILURE STATE
S1003
START SENDING SYSTEM SWITCHING INSTRUCTION
S1004
TRANSITION TO SYSTEM SWITCHING STATE
SYSTEM SWITCHING REQUEST FRAME
34001-1
34001-2
S1005
TRANSITION TO SYSTEM SWITCHING STATE
S1006
START SENDING SYSTEM SWITCHING INSTRUCTION
SYSTEM SWITCHING INSTRUCTION FRAME
34002-1
34002-2
S1007
SWITCH UPLINK SENDING PATH
S1008
CONFIRM THAT RECEPTION IS RESUMED, AND FINISH SYSTEM SWITCHING STATE
34003-1
NOTIFY SYSTEM SWITCHING COMPLETION
S1009
FINISH SYSTEM SWITCHING STATE
S1010
FINISH SENDING SYSTEM SWITCHING INSTRUCTION

FIG.35

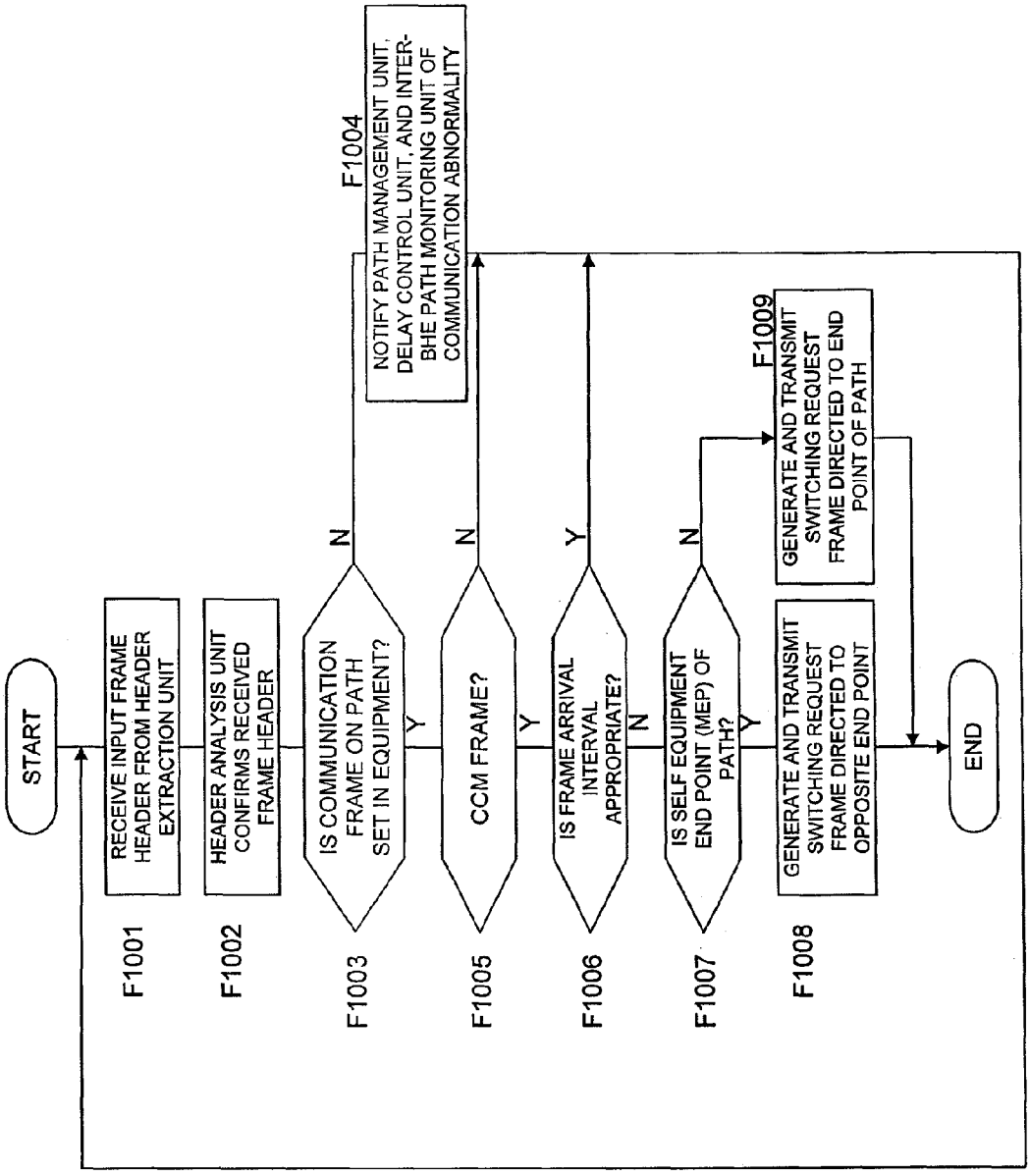

START
F1001
RECEIVE INPUT FRAME HEADER FROM HEADER EXTRACTION UNIT
F1002
HEADER ANALYSIS UNIT CONFIRMS RECEIVED FRAME HEADER
F1003
IS COMMUNICATION FRAME ON PATH SET IN EQUIPMENT?
N
F1004
NOTIFY PATH MANAGEMENT UNIT, DELAY CONTROL UNIT, AND INTER-BHE PATH MONITORING UNIT OF COMMUNICATION ABNORMALITY
Y
F1005
CCM FRAME?
N
Y
F1006
IS FRAME ARRIVAL INTERVAL APPROPRIATE?
N
Y
F1007
IS SELF EQUIPMENT END POINT (MEP) OF PATH?
N
F1009
GENERATE AND TRANSMIT SWITCHING REQUEST FRAME DIRECTED TO END POINT OF PATH
Y
F1008
GENERATE AND TRANSMIT SWITCHING REQUEST FRAME DIRECTED TO OPPOSITE END POINT
END

FIG.36

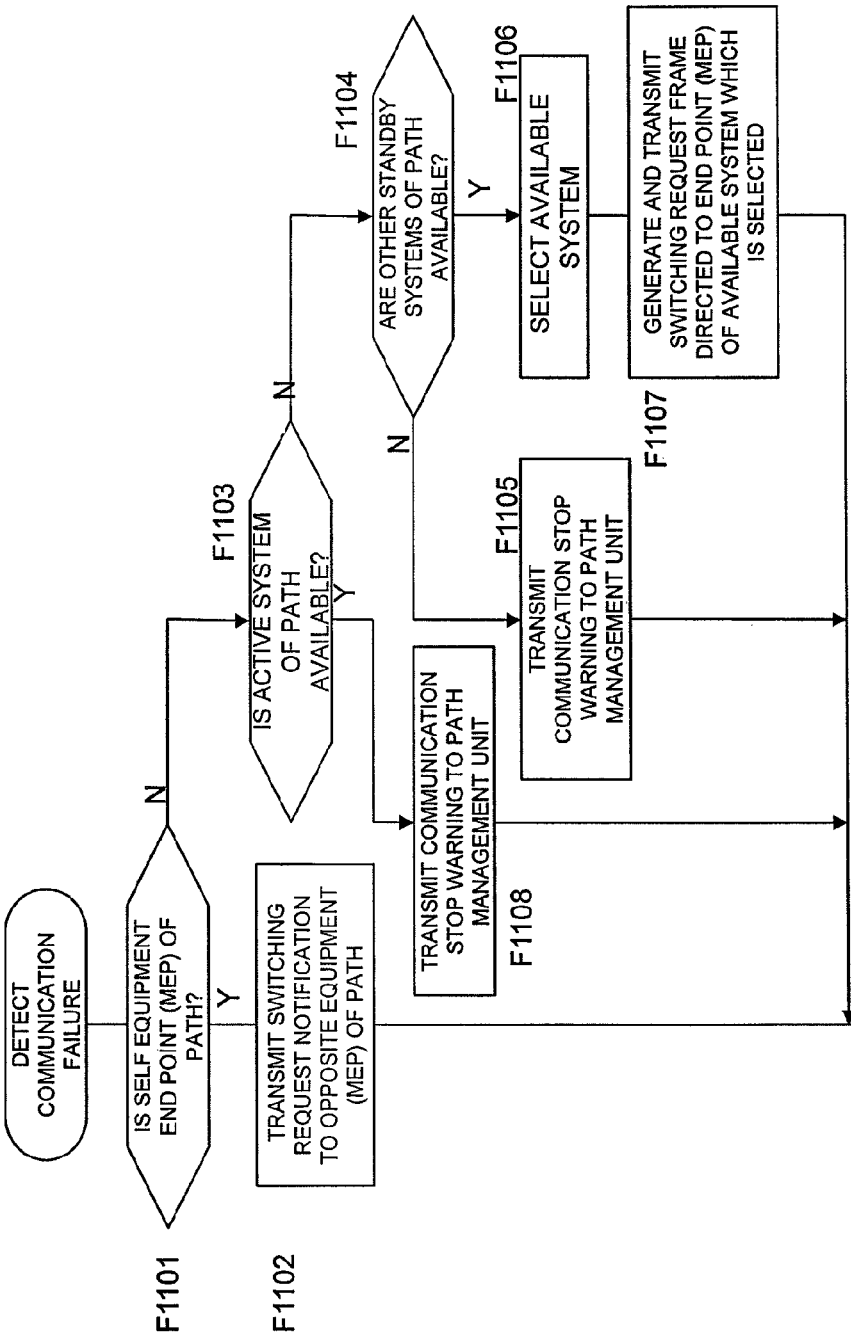

DETECT COMMUNICATION FAILURE
IS SELF EQUIPMENT END POINT (MEP) OF PATH?
F1101
N
Y
TRANSMIT SWITCHING REQUEST NOTIFICATION TO OPPOSITE EQUIPMENT (MEP) OF PATH
F1102
IS ACTIVE SYSTEM OF PATH AVAILABLE?
F1103
N
Y
ARE OTHER STANDBY SYSTEMS OF PATH AVAILABLE?
F1104
N
Y
TRANSMIT COMMUNICATION STOP WARNING TO PATH MANAGEMENT UNIT
F1105
TRANSMIT COMMUNICATION STOP WARNING TO PATH MANAGEMENT UNIT
F1108
SELECT AVAILABLE SYSTEM
F1106
GENERATE AND TRANSMIT SWITCHING REQUEST FRAME DIRECTED TO END POINT (MEP) OF AVAILABLE SYSTEM WHICH IS SELECTED
F1107
END

FIG.37

COMMUNICATION NETWORK SYSTEM AND COMMUNICATION NETWORK CONFIGURATION METHOD

TECHNICAL FIELD

The present invention relates to a communication network system and a communication network configuration method. The present invention relates particularly to a relay network which accommodates a plurality of subscriber networks and can connect the subscriber network to high-speed interconnect networks of telecommunications carriers, or the subscriber network to backbone networks of various service providers, information delivery service networks or other subscriber networks such that subscribers enjoy a variety of on-line services, and relates to means for improving communication reliability and quality in the relay network (a method of communication path redundancy and path switching when communication failures occur).

BACKGROUND ART

With the increase in demands for communication using broadband, a user-oriented access line has been shifted to a large capacity access line using an optical fiber instead of an access technique which is based on a telephone line such as a Digital Subscriber Line (DSL). Currently, a Passive Optical Network (PON) system (hereinafter, referred to as a PON simply, an optical passive network system, or a passive optical network system in some cases) is frequently used for an access line service in terms of line construction costs and maintenance and management costs. For example, standardization in International Telecommunication Union Telecommunication Standardization Sector (ITU-T) is a representative example. The Western countries have started to introduce Gigabit PON (GPON) since around 2006.

With the increase in opportunities for home users (communication service subscribers) to access the Internet and collect information or use information services required for social lives, there have been requests for preparation for communication networks, particularly, completion of access network providing services which connect subscribers to communication networks. That is, carriers, which provide the communication networks, are required to increase capital for increasing the number of users accommodated in each station along with an increase in the number of users of access lines. In order to increase the number of users, a method of additionally introducing the PON or of increasing the number of users accommodated in each PON system has been examined. In relation thereto, next generation PON techniques called 10 Gigabit PON (10GPON) and 10 Gigabit Ethernet (registered trademark) PON (10GEPON) have been examined as means for performing transmission at a higher bit rate than in the related art in ITU-T and Institute of Electrical and Electronics Engineers (IEEE).

The above-described subscriber accommodation equipment is installed in a building of a communication carrier. In order to relay a connection between a subscriber and an opposite device (another user, a web server, or the like), typically, there is a network configuration in which a signal from a subscriber is input to a relay transmission network (hereinafter, referred to as a relay network in some cases) from the subscriber accommodate equipment, and, simultaneously, a signal is transferred in an opposite direction to the signal, and thereby the user can obtain information. The relay network is connected to provider networks or core networks, and plays a role of distributing a user signal to one or more

provider networks or core networks and transferring a signal from the provider networks or the core networks to the user in a reverse direction. This relay network is called an access network or a backhaul.

Although a dedicated line service using an Asynchronous Transfer Mode (ATM), frame relay, SONET/SDH, or the like is frequently used for a user network in the related art, recently, a low-priced packet communication network exemplified by Ethernet (registered trademark) has been frequently used with an increasing request for cost reduction and the progress of a communication technique and a device manufacturing technique which can handle expanded transmission capacity. On the other hand, SONET/SDH is the mainstream as a communication technique inside a core network, and forms a large capacity and high reliability network in order to transmit data which is collected via a plurality of access networks.

In recent years, along with becoming widespread of the Internet, a packet (or also referred to as a frame) communication technique exemplified by Ethernet (registered trademark) and Multi Protocol Label Switching (MPLS) has progressed and attracted attention as a base technique for forming a communication network. Features of the packet network lie in ease of handling or reduction in development (introduction) costs. In addition thereto, circumstances in which a standard technique which targets a packet communication technique and is related to maintenance and management is being established are main causes for the communication carriers to introduce and expand the packet communication technique. Definition or the like of the above-described maintenance and management function or a function of the packet communication network has been discussed in the standardization groups such as ITU-T, IEEE, and The Internet Engineering Task Force (IETF).

CITATION LIST

Patent Literature

Patent Literature 1: JP-A-2008-219496

SUMMARY OF INVENTION

Technical Problem

An object of the present invention is to provide a redundancy method of a communication path for suppressing consumption of network resources such as communication lines or communication equipment (signal processing performance) to the minimum in a relay network in a case of performing redundancy of the communication path in order to secure continuity of a communication service, in the relay network (backhaul) which accommodates user sites and access lines built by various communication techniques such as wireless access, Ethernet (registered trademark), MPLS, PON, MC, xDSL, ATM, and SONET/SDH and is used to provide communication paths on which various services over the Internet via an Internet Service Provider (ISP) network or a core network can be used. Particularly, the relay network (backhaul) has a function of linking a plurality of access lines, and thus a topology of the paths gives one-to-multi connection. In relation to communication network redundancy (protection) in one-to-multi connection, for example, if the related art disclosed in Patent Literature 1 or the like is used, there is a means such as preparation of a set of standby tree type communication networks; however, in this related art, a main constituent is a means for securing a plurality of paths

which have low possibility of actual use or of making only some of the paths forming a tree redundant so as to be protected.

In light of the above-described problems, an object of the present invention is to provide a redundant communication network system and a communication network configuration method capable of minimizing wasting of network resources and protecting all tree type paths formed in a relay network.

Solution to Problem

In a communication system of the present invention, for example, edge equipment included in a relay network is classified into two types. One is access line side edge equipment (AE) that accommodates an access line, and the other is a backhaul edge equipment (BHE) which provides communication means with an ISP network or a core network side (a so-called WAN side). The BHE is located at the top of a tree structure formed in a relay network, and includes communication paths with the plurality of AEs. In addition, the AE includes a communication path for one or more BHEs, and belongs to one or more trees. Each of the AE uses one of a plurality of trees (BHE) to which the AE belongs as an active system, and sets a priority for the other trees (BHE) which are used as standby system paths. Further, there is provided an intercommunication path for mutually transmitting and receiving a signal between the BHEs each of which is a top of the tree. When failures occur in the active system path in certain AE, the standby system path (BHE) relays communication between the AE and the (active system) BHE so as to secure continuity of communication. The intercommunication path through which a data signal does not flow in a normal operation is used as a traffic accommodation path in an emergency between the BHEs. By setting a bypass between the tops of the trees, when a failure occurs in one tree, a signal is transferred from the active system BHE to the standby system path in which another BHE is a top so as to build a sub-tree (hierarchical tree) bypassing the failure point and to secure the communication path. The reason why a plurality of BHEs are provided and the bypass between the BHEs is used is that, although a communication path is built through connection between a plurality of management domains in a typical communication network, in this case, a method of monitoring the inside of the management domain and a connection section between the domains is a basic method in defining a responsibility dividing point. In other words, this is because, even if a communication path inside the management domain varies, the variation is confined in a single management domain, and a specific device (or a specific interface) which provides an external interface does not vary, which is a preferable form in terms of an operation (in terms of connection contract between carriers).

According to the first solving means of the present invention, there is provided a communication network system, and a communication network configuration method using the communication network system comprising:

a plurality of edge equipments (AEs) on an access line side that accommodate an access line; and

a plurality of backhaul edge equipments (BHEs) connected to a network side,

wherein each of the BHEs

is located at a top of a tree structure formed in a relay network including the plurality of AEs, and includes communication paths with the plurality of AEs;

includes an intercommunication path through which a data signal does not flow in a normal operation and a data signal is mutually transmitted and received as a traffic accommodation path in an emergency between each of the plurality of BHEs, each of which is a top of the tree structure; and

includes a BHE transfer table which stores in advance a correlation between an input communication path and an output communication path, and an inter-BHE path table which stores in advance a correlation between an input communication path and an output communication path in the intercommunication path,

wherein each of the plurality of AEs

has communication paths for the plurality of BHEs, and is connected to the plurality of BHEs in advance via paths independent from one another;

sets an active system path for one of the plurality of BHEs which are tops of a plurality of tree structures to which the self AE belongs, and sets a standby system path for one or a plurality of BHEs among the other BHEs;

wherein

the AE, in a normal operation state, receives data communication from a first BHE, and periodically receives a connection checking frame for checking normality of a communication path in order to monitor communication circumstances of a first communication path between the AE and the first BHE;

the AE determines that a failure occurs in the first communication path when a subsequent connection checking frame is not received until a specific time has elapsed; and

the AE sends a path switching request frame to a second BHE using a second communication path with the second BHE in which abnormality is not recognized on the communication path,

wherein,

when the second BHE receives the path switching request frame transmitted by the AE,

the second BHE recognizes that some sort of problem which disrupts continuous communication between the AE and the first BHE occurs;

the second BHE makes the second communication path connected between the AE and the second BHE valid as a main signal path in a second BHE transfer table in the second BHE, sets a communication path directed to the AE using the intercommunication path connecting the first BHE and the second BHE for a downlink signal to the AE, and changes settings so as to set a transmission path by the intercommunication path for an uplink signal from the AE; and

the second BHE further transmits a transfer request frame for accommodating communication which is directed to the AE from the first BHE in the intercommunication path, to the first BHE,

wherein,

when the first BHE receives the transfer request frame from the second BHE, the first BHE changes settings in the first BHE transfer table in the first BHE so as to switch a path, which receives an uplink signal from the AE, from the first communication path to the intercommunication path; and

the first BHE further changes settings in the first BHE transfer table so as to transfer a downlink signal directed to the AE received from the network to the intercommunication path, in relation to the downlink signal to the AE which has been transferred using the first communication path connecting the first BHE to the AE, and

wherein a sub-tree having a sub-tree structure in which the second BHE of a standby system by passing a failure point is placed as a top is built under the first BHE of an active system, and communication between the AE and the first BHE of the active system is relayed by a standby system path via the second BHE of the standby system.

According to the second solving means of the present invention, there is provided a communication network system, and a communication network configuration method using the communication network system comprising:

a plurality of edge equipments (AEs) on an access line side that accommodate an access line; and

a plurality of backhaul edge equipments (BHEs) connected to a network side,

wherein each of the BHEs

is located at a top of a tree structure formed in a relay network including the plurality of AEs, and includes communication paths with the plurality of AEs;

includes an intercommunication path through which a data signal does not flow in a normal operation and a data signal is mutually transmitted and received as a traffic accommodation path in an emergency between each of the plurality of BHEs, each of which is a top of the tree structure; and

includes a BHE transfer table which stores in advance a correlation between an input communication path and an output communication path, and an inter-BHE path table which stores in advance a correlation between an input communication path and an output communication path in the intercommunication path,

wherein each of the plurality of AEs

has communication paths for the plurality of BHEs, and is connected to the plurality of BHEs in advance via paths independent from one another;

includes an AE transfer table which stores in advance a correlation between an input communication path and an output communication path, sets an active system path for one of the plurality of BHEs which are tops of a plurality of tree structures to which the self AE belongs, and sets a standby system path for one or a plurality of BHEs among the other BHEs;

wherein

a first BHE, in a normal operation state, receives data communication from the AE, and periodically receives a connection checking frame for checking normality of a communication path in order to monitor communication circumstances of a first communication path between the AE and the first BHE;

the first BHE determines that a failure occurs in the first communication path when a subsequent connection checking frame is not received until a specific time has elapsed; and

the first BHE sends a transfer request frame to the second BHE using an intercommunication path connected to the second BHE,

wherein,

when the second BHE receives the transfer request frame transmitted by the first SHE,

the second BHE recognizes that some sort of problem which disrupts continuous communication between the AE and the first BHE occurs;

the second BHE makes the second communication path connected between the AE and the second BHE valid as a main signal path in a second BHE transfer table in the second BHE, sets a communication path directed to the AE using the intercommunication path connecting the first BHE and the second BHE for a downlink signal to the AE, and changes settings so as to set a transmission path by the intercommunication path for an uplink signal from the AE; and

the second BHE further sends a switching instruction frame to the AE so as to switch an uplink signal sending path from the first communication path to a second communication path with the second BHE, in which abnormality is not recognized on the communication path, and

wherein the AE changes settings in the AE transfer table so as to switch an uplink signal sending path from the first communication path to the second communication path with the second BHE, in which abnormality is not recognized on the communication path, when the switching instruction frame is received, and

wherein,

on the other hand, the first BHE changes settings in the first BHE transfer table in the first BHE so as to switch a path, which receives an uplink signal from the AE, from the first communication path to the intercommunication path; and

the first BHE further changes settings in the first BHE transfer table so as to transfer a downlink signal directed to the AE received from the network to the intercommunication path, in relation to the downlink signal to the AE which has been transferred using the first communication path connecting the first BHE to the AE, and

wherein a sub-tree having a sub-tree structure in which the second BHE of a standby system by passing a failure point is placed as a top is built under the first BHE of an active system, and communication between the AE and the first BHE of the active system is relayed by a standby system path via the second BHE of the standby system.

Further, according to the present invention, it is possible to provide a communication network system, and a communication network configuration method using the communication network system, according to the above-mentioned communication network system and the above-mentioned communication network configuration method,

wherein, in a case where the AE has already been connected to the first BHE via the second communication path and the second BHE due to a failure regarding the first communication path connecting the AE to the first BHE,

when the second BHE detects a failure regarding the second communication path according to stop of periodical reception of a connection checking frame which is transmitted from the AE to the second BHE,

the second BHE sends a switching request frame to the third BHE using the intercommunication path,

wherein,

when the third BHE receives the switching request frame transmitted by the second BHE,

the third BHE recognizes that some sort of problem which disrupts continuous communication between the AE and the second BHE occurs;

the third BHE makes the third communication path connected between the AE and the third BHE valid as a main signal path in a third BHE transfer table in the third BHE, sets a communication path directed to the AE using the intercommunication path connecting the first BHE and the third BHE for a downlink signal to the AE, and changes settings so as to set a transmission path by the intercommunication path for an uplink signal from the AE; and

the third BHE further sends a switching instruction frame to the AE so as to switch an uplink signal sending path from the first communication path to a third communication path with the third BHE, in which abnormality is not recognized on the communication path, and

wherein the AE changes settings in the AE transfer table so as to switch an uplink signal sending path from the first communication path to the second communication path with the second BHE, in which abnormality is not recognized on the communication path, when the switching instruction frame is received, and

wherein,

on the other hand, the first BHE changes settings in the first BHE transfer table in the first BHE so as to switch a path,

which receives an uplink signal from the AE to the intercommunication path connected to the third BHE; and

the first BHE further changes settings in the first BHE transfer table so as to transfer a downlink signal directed to the AE received from the network to the intercommunication path connected to the third BHE, in relation to the downlink signal to the AE, and

wherein a sub-tree having a sub-tree structure in which the third BHE of a standby system by passing a failure point is placed as a top is built under the first BHE of an active system, and communication between the AE and the first BHE of the active system is relayed by a standby system path via the third BHE of the standby system.

Advantageous Effects of Invention

According to the present invention, in the relay network collecting access lines, an intercommunication path between BHEs which provides a WAN side interface is used for path protection when failures occur. The BHE is a collection point of communication in the relay network, and thus failures in an important communication path can be grasped in this collection point (BHE). A bypass is provided between the BHEs by using this feature, and thereby it is possible to promptly handle (change a communication path) communication failures which have occurred in the relay network. In addition, communication circumstances between the collection point and a plurality of AEs are monitored in each communication path, and thereby there is an effect of preventing influence of failures in some communication paths from being exerted on the overall relay network. For example, when a failure is detected in a certain AE, the above-described sub-tree configuration is applied to the AE only, and thus only a signal addressed to the AE flows through the bypass between the BHEs. Therefore, it is possible to prevent extra instantaneous communication interruption in communication between AE in which there is no extra load on the bypass or failure and BHE. In addition, in the present invention, only the bypass between BHEs is a standby system path which is not used for a normal operation, and thus it is not necessary to make all the trees redundant unlike in the related art, and it is possible to efficiently distribute resources. Further, since almost overall communication in the relay network can be protected, it is possible to satisfy a plurality of requests together which are contradictory to the concept in the related art in one-to-multi communication.

BRIEF DESCRIPTION OF DRAWINGS

FIG. **1** shows an example of the configuration diagram of a communication network using a relay network (backhaul) for accommodating access lines.

FIG. **2** shows the enlarged relay network **10** of FIG. **1** and is a network configuration diagram illustrating an example in which lines and equipments are disposed in the relay network **10**.

FIG. **3** is a communication path configuration diagram illustrating a path switching method in a case where connectivity is not confirmed in the communication circumstances checking process described in FIG. **2**.

FIG. **4** is a communication path configuration diagram illustrating a standby system path configuration method in a case where connectivity is not confirmed in the communication circumstances checking process described in FIG. **2**.

FIG. **5** is a sequence diagram illustrating a flow of processes related to path switching between AE **112** and BHE **172** in the network configuration diagram of FIG. **3**.

FIG. **6** is a sequence diagram illustrating a flow of processes different from FIG. **5**, related to path switching between the AE **112** and the BHE **172** in the network configuration diagram of FIG. **3**.

FIG. **7** is a sequence diagram illustrating a flow of processes related to a transfer path resetting process between BHE **171** and BHE **172** in the sequence diagram of FIG. **6**.

FIG. **8** is a sequence diagram illustrating a flow of processes different from FIG. **7**, related to a transfer path resetting process between the BHE **171** and the BHE **172** in the sequence diagram of FIG. **6**.

FIG. **9** is a sequence diagram illustrating path setting change procedures of the BHE **171** in the path switching process shown in FIGS. **5** to **8**.

FIG. **10** is a block configuration diagram illustrating a configuration example of the user side edge equipment AE of the relay network **10** which accommodates access lines.

FIG. **11** is an explanatory diagram illustrating a configuration example of the transfer table **1110** of a reception signal held by a path control unit **1100** of AE **112** of FIG. **10**.

FIG. **12** is an explanatory diagram illustrating a configuration example (A) of the management table **1310** held by a path management unit **1300** forming a controller **1000** of the AE **112**.

FIG. **13** is an explanatory diagram illustrating another configuration example (B) of the management table **1310** held by the path management unit **1300** forming the controller **1000** of the AE **112**.

FIG. **14** is a configuration example of the delay table **1210** held by a delay control unit **1200** forming the controller **1000** of the AE **112**.

FIG. **15** is an explanatory diagram illustrating a mutual relationship among the respective management tables shown in FIGS. **11** to **14**.

FIG. **16** is a flowchart illustrating a flow of processes related to setting path information in the AE **112**.

FIG. **17** is a flowchart illustrating processes related to a path monitoring frame (a CCM frame) in a header analysis unit **2260** of the AE **112**.

FIG. **18** is a flowchart illustrating process procedures of a user data frame in the header analysis unit **2260** of the AE **112**.

FIG. **19** is a flowchart regarding an information process of the path monitoring frame (CCM frame) in a failure monitoring unit **1400** of the AE **112**.

FIG. **20** is a flowchart illustrating process procedures related to transfer of a received frame in the delay control unit **1200** of the AE **112**.

FIG. **21** is a block configuration diagram illustrating a configuration example of ISP network/core network side edge equipment BHE of the relay network **10** which accommodates access lines.

FIG. **22** is a table configuration diagram illustrating a configuration example of the inter-BHE path table **5510** in the functional block of the BHE **172** of FIG. **20**.

FIG. **23** is an explanatory diagram illustrating a configuration example (A) of the management table **5310** held by a path management unit **5300** in a controller **5000** of the BHE **172** (FIG. **20**).

FIG. **24** is an explanatory diagram illustrating a configuration example (B) of the management table **5310** held by the path management unit **5300** in the controller **5000** of the BHE **172**.

FIG. **25** is a flowchart illustrating a flow of processes related to setting path information in the BHE **172**.

FIG. **26** is a flowchart illustrating process procedures when a path switching request **20001** is received by a header analysis unit **6260** of the BHE **172**.

FIG. **27** is a flowchart illustrating procedures of the path switching process when a path switching request frame is received by the CTR **5000** of the BHE **172**.

FIG. **28** is a signal configuration diagram illustrating a configuration example of the frame used for communication between the BHE **172** and the BHE **171** when using a standby path **970**.

FIG. **29** is a signal configuration diagram illustrating a configuration example of the CCM frame.

FIG. **30** is a signal configuration diagram illustrating a configuration example of the switching request frame **20001**, transfer request frame **20002**, and process completion notification (ACK) frames **30000** and **40000**.

FIG. **31** is a network configuration diagram illustrating a path switching method in a case where failures in uplink communication are recognized from arrival circumstances of a CCM signal when the BHE **171** monitors a CCM frame from the AE **112**.

FIG. **32** is a sequence diagram illustrating a flow of a path switching process in a second embodiment.

FIG. **33** is a network configuration diagram illustrating a state in which three or more relay network edge equipment BHEs on the core networks **210** and **220** side are connected to a single access side edge equipment AE in the relay network **10** of FIG. **1**.

FIG. **34** is a communication path configuration diagram illustrating a standby system path configuration method in a case where connectivity is not confirmed due to a second failure **300-2** in the communication circumstances checking process described in FIG. **32**.

FIG. **35** is a sequence diagram illustrating a flow of a path switching process in the path configuration example of FIGS. **33** and **34**.

FIG. **36** is a flowchart illustrating process procedures when a data frame or a control (for example, CCM) frame is received by a header analysis unit **6260** of the BHE **172**.

FIG. **37** is a flowchart illustrating procedures of a path switching process in the path control unit when the BHE **172** detects the failure **300-2**.

DESCRIPTION OF EMBODIMENTS

A. First Embodiment

1. System

1-1. System Configuration

FIG. **1** shows a network configuration which is assumed in the present embodiment. This figure shows a configuration example of the communication network using a relay network (backhaul) for accommodating access lines. The network configuration using the relay network **10** is a general configuration in a communication carrier network which accommodates an access line **60** which connects a base station for mobile service to a carrier building, or a user site to the carrier building. A scheme of realizing the access line **60** includes PON, Media Converter (MC), and wireless access. The PON system is constituted by optical fibers **631**, **632**, **633** and **634** and an optical splitter **630**. In this figure, Access Edge Equipment (AE) **113** is PON subscriber accommodation equipment, and Network Terminals (NTs) **421** and **431** correspond to subscriber devices. The NTs **411**, **421** and **431** are line collecting devices in user networks, for respectively connecting a user network **410**, a user network **420**, and other user networks to the relay network **10**. The optical fiber **631** forming the PON is referred to as a line collecting optical fiber, and the optical fibers **632** to **634** are referred to as branch line optical fibers. The MC is a communication form used for connection of an optical fiber in one-to-one type, and this figure shows a state in which AE **112** and the NT **411** are connected to each other with the MC technique as an example (the line **621** is an optical fiber). The wireless access is a communication scheme for connecting wireless base stations (BSs) **311** and **321** which are connected to the AE **111** via the lines **611** and **612**, to the user network or user terminals **310** and **320**, in this figure. An access function for accommodating the user network **310** including the BSs **311** and **321** or the user terminal **320** is referred to as a wireless access site (Cell Site) **800**. In the wireless access site **800**, various communication schemes using a metal line or an optical fiber are used as connection schemes of the AE **111** and the BSs **311** and **321**, and, in recent years, a scheme of accommodating a plurality of BSs using the PON system has started to be introduced. In this figure, lines connected to the AEs **111**, **112**, **113** and **121** are collectively referred to as the access lines **60**.

In addition, this figure shows core networks **210** and **220**. In the present embodiment, core network edge equipments (CoRe Edge Equipment (CRE)) **211** and **221** provide connection points to different Internet Service Providers (ISPs), the edge equipments **211** and **221** do not perform intercommunication. This is because whether or not direct signal transmission and reception between the edge equipments are performed does not influence implementing the present invention and the present embodiment. In description of a path protection operation of the communication system of the present embodiment, a network configuration as simple as possible is assumed. Further, there may be another core network, and, there is CRE **231** as an example thereof in this figure. In addition, a network configuration example is shown in a case where connection between still another core network (not shown) and the relay network **10** (via the BHE **171** or **172**) or a relay network **20** (via BHE **181**) is performed.

There is a use of the relay network (an access network or backhaul) **10** which accommodates the access line **60** and is used to relay communication between the user networks **310**, **320**, **410** and **420** and the core networks **210** and **220**. The relay network **10** has an access line accommodation function and a function of connection to the core network in order to provide the above-described relay function. In addition, the relay network has a function of connecting the user networks (including company sites; general users using the communication network in this configuration of the figure and users on business are hereinafter collectively referred to as users) collected in the access line accommodation equipment AEs **111** to **113** and **121**, to edge equipments (Backhaul Edge Equipment (BHE)) **171**, **172** and **181** which provide core network side interfaces. A specific example of the line collecting function will be described with reference to this figure. The BHE **171** has a function of temporarily collecting communication signals from the access lines accommodated by the AEs **111**, **112** and **113** before being transferred to the core networks **210** and **220**, selecting a necessary transfer destination (core network), and transferring the signals to the core network side edge equipment CREs **211**, **221** and **231**. The BHE **172** also accommodates communication with the user networks collected in the same AEs **111** to **113** via the access line **60**. In other words, the user networks are collected in the AEs **111** to **113** via the access lines, and communication with the core networks **210** and **220** from the AEs **111** to **113** via the relay network **10** is collected in the core network side edge equipment BHEs **171** and **172** of the relay network **10**. As such, the communication with the core network via the relay network **10** has a tree structure in which the BHEs **171** and **172** are some tops. The CRE **231**, the BHE **181**, and the AE **121** also have the same function, the access lines **60** accommodated in the AE **121** are collected in the BHE **181** in the tree structure,

and thus communication with the core network side edge equipment CRE **231** can be performed. Hereinafter, the relay network **20** is assumed to have a function equivalent to the relay network **10**, and thus description of the relay network **10** is also applied to the relay network **20**. This figure is aimed at showing communication with a plurality of core networks including the core networks **210** and **220** from the relay network **20** as well, and the relay network **10** is a target of description since a function unique to only the relay network **20** is not particularly necessary in the present embodiment.

In the relay network **10**, the BHEs **171** and **172** accommodate respectively the same AEs **111**, **112** and **113** in building a tree structure in which the BHE is a top. In other words, when viewed from the AEs **111**, **112** and **113**, there are communication paths of two directions from the AE to the BHE. In this configuration, the AEs **111**, **112** and **113** belong to both of two tree type communication paths in which the BHEs **171** and **172** are tops. The BHEs **171** and **172** maintain communication paths with the core networks which can be connected by the interconnection **90** with the core networks, and thus the AEs **111** to **113** can communicate with the core networks via any of the BHE (**171** or **172**). Although it is assumed that there are lines for connection between the BHE **171** and the CRE **231**, the BHE **181** and the CRE **211**, they are not shown for easy view.

The relay network **10** is realized using a packet communication technique. The packet communication technique may employ Ethernet (registered trademark), MPLS, or the like. In the present embodiment, maintenance and management of a transfer network is preferentially taken into consideration, and a case where the relay network **10** is formed using the MPLS technique is assumed. In addition, operations and effects of the present invention and the present embodiment are not limited to a case of employing an MPLS protocol, and can also be realized using an Ethernet (registered trademark) line or a Virtual LAN (VLAN) which is a logical line thereof. In the present embodiment, a maintenance and management (OAM) function which can be applied to a communication path is provided, and the operations and the effects can be realized using all communication techniques having an OAM function equivalent to the OAM function described below.

As described above, the AEs **111** to **113** may be connected to the core network via either of the BHEs **171** and **172** in this configuration example. In this figure (FIG. **1**), it is assumed that, in a normal operation state, the AEs **111** and **112** perform communication with the core network via the BHE **171**, and the AE **113** is in a state of being capable of communicating with the core network through connection to the BHE **172**. To differently use the BHEs **171** and **172** is aimed at reducing an equipment load on the BHE. Since both the BHEs **171** and **172** play a role of collecting signals from users and distributing the signals to the core networks **210** and **220**, they are required to work always at a high load. For this reason, it is generally desirable to differently use a plurality of BHEs. Of course, in a case where the BHE can be expected to have a sufficient process performance, for example, only the BHE **171** can process whole communication of the AEs **111** to **113**. In this case, the BHE **172** stands by as a standby system, and is used as replacement equipment when the BHE **171** breaks down or a failure occurs in communication between the AEs **111**, **112** and **113** and the BHE **171**.

Hereinafter, a connection relationship inside the relay network **10** will be described in the network configuration example of this figure. The relay network **10** is formed by combining a plurality of transmission equipments. In lines **911**, **912**, **921**, **922**, **931** and **932** which connect the AEs **111** to **113** and the BHEs **171** and **172**, the AE may be directly connected to the BHE, and or one or more communication equipments (or also referred to as relay equipment which is not shown) may be present between the AE and the BHE. Therefore, the lines **911**, **912**, **921**, **922**, **931** and **932** may indicate physical layer links and may indicate logical connection passing through a plurality of relay equipments. Hereinafter, they are not particularly differentiated from each other and are referred to as lines.

Now, it is assumed that the AEs **111** and **112** belong to a tree of the BHE **171**. In other words, the AEs **111** and **112** perform communication with the BHE **171** using the lines **911** and **921**. In addition, the AE **113** performs communication with the BHE **172** using the line **932**. Further, the lines **912**, **922** and **931** which are not used for the operation are lines used in an emergency when communication failures occur inside the relay network **10** or delay is expanded due to congestion, or when equipment failures occur in the BHE **171** or the BHE **172** or a load increases.

Next, a description will be made of a line configuration example between the relay network **10** and the core networks **210** and **220**. In this figure, the BHE **171** and the CREs **211** and **221** are respectively connected to the lines **711** and **712**. Here, it is assumed that a configuration method of the interconnection **90** mainly employs connection using a physical line. A practical operation configuration may be a configuration in which logical lines such as a plurality of VLANs, MPLS paths or Pseudo Wires (PWs) are multiplexed on a physical line, but a line used for connection between the BHE and the CRE is generally directly connected thereto, and the configuration example of this figure indicates a connection relationship of such a line. Similarly, the BHE **172** is connected to the CREs **211**, **221** and **231** via the lines **721**, **722** and **723**, respectively. In addition, the BHE **181** is connected to the CREs **221** and **231** via the lines **732** and **733**, respectively. Communication circumstances regarding the BHE **171** and the BHE **172** of interest in the configuration example of this figure are acquired. The BHE **171** relays communication with the CREs **211** and **221** from the AEs **111** and **112**, and thus distributes a signal from the AE **111** or the AE **112** to the CRE **211** or the CRE **221** based on destination information of the signal. In communication in a reverse direction, a signal from the CRE **211** or the CRE **221** is distributed to the AE **111** or the AE **112** based on destination information of the signal. This is also the same for the BHE **172** which distributes communication from the AE **113** to the CREs **211**, **221** and **231** and also transfers a signal from the CREs **211**, **221** and **231** to the AE **113**. As described above, all the lines are used to transmit signals in the interconnection **90** at all times.

In the relay network **10**, the AEs **111** to **113** can select any one from a plurality of paths (here, two paths) when communication to the core networks **210** and **220** is performed. To use either one path is aimed at reducing extra signal processes in order to make valid a transmission capacity of the relay network **10** which is a packet communication network to the maximum. For this reason, the AEs **111** to **113** are respectively provided with databases (hereinafter, the database is also referred to as a DB) **511**, **512** and **513** for path selection (system selection). For the above-described reason, these databases are updated using variations in signal process circumstances in the relay network or the BHE as triggers and are operated such that a communication service which is currently provided to a user does not stop to the extent possible. On the other hand, the BHEs **171**, **172** and **181** are provided with failure management DBs (**571**, **572** and **581**). These DBs are used to monitor whether or not communication circumstances of one or more AEs connected to each BHE and a communication state in the lines (the interconnec-

tion **90**) for transferring a signal from the BHE to the core network are normal, and to determine whether or not to change transmission paths from the BHE to the core networks **210** and **220** or communication paths from the BHE to the AEs **111** to **113**. These DBs periodically monitor a communication state in each line and hold records regarding whether or not a physical connection state of the line is normal, or variations in a communication performance due to congestion or the like, in order to perform the above-described determination.

FIG. **2** shows the enlarged relay network **10** of FIG. **1** and is a network configuration diagram illustrating an example in which lines and equipments are disposed in the relay network **10**. With reference to this figure, a description will be made of a maintenance and management method in the relay network in the configuration of FIG. **1**. Each path is set to be identified independently in the relay network **10** by an identifier (label) of Label Switched Path (LSP) provided in a SIMM header of the MPLS.

In the paths **911**, **912**, **921**, **922**, **931** and **932** formed in the relay network **10**, a Continuity Check Message (CCM) frame is periodically transmitted in order to check normality of the packet communication path, and it is checked whether or not transmission and reception are performed as set by an administrator (as expected). The CCM frame is also referred to as a Continuity Check (CC) message or a Connectivity Verification (CV) frame. In the present embodiment, the name for a frame for checking communication normality is unified to a CCM frame. The CCM frame **10000** is periodically issued from equipment which is an end point of each path, and opposite terminal end equipment confirms arrival of the CCM frame. When the arrival can be confirmed, an arrival time point and an arrival interval are further confirmed, and it is determined whether or not a communication performance of the line is maintained.

This figure shows a communication state management method of a triangular path formed by the AE **112** and the BHEs **171** and **172** in order to show a state in which the CCM frame **10000** is transmitted and received. Here, the AE **112** is described as a representative example, and a transmission and reception method of the CCM frame to and from the BHEs **171** and **172** is also the same for the AEs **111** to **113**. Hereinafter, attention is paid to a signal process in communication between the AE **112** and the BHEs **171** and **172**, and this will be described as a representative example.

In the MPLS (Ethernet (registered trademark) OAM regulations: the same process is performed even using ITU-T Recommendation Y.1731), a communication direction is clearly differentiated. In a case of the MPLS, the identity of a flow is verified based on a combination of an input interface identifier and an input label value by using a table held in a transfer table (FIG. **10**: **1110**) provided in the communication equipment. Similarly, a flow is identified based on a combination of an output interface identifier and an output label value. Therefore, the relay equipment in the relay network **10** holds the transfer table (FIG. **10**: **1110**) in which an input flow which can be verified from an input interface identifier and an input label value is correlated with an output interface identifier and an output label value for outputting the flow. Thus, for example, there is a possibility that a communication signal (including the CCM frame) from the AE **112** to the BHE **171** and a communication signal (including the CCM frame) from the BHE **171** to the AE **112** may pass through the same physical line, and there is a possibility that the signals may pass through paths (physically) different from each other and be transmitted and received in a case where a plurality of physical lines are installed. The present invention and the present embodiment are not required to be limited to any configuration. In any case, a transmission side may send the CCM frame at a constant transmission interval, and a reception side may check whether or not the frame is received at a normal time interval. In addition, in order to clearly show an operation (a difference in replacement path configuration methods due to the failure circumstances when communication failures occur) to which the present invention and the present embodiment are applied, a case where physical lines are different depending on a communication direction will be described as an example in the present embodiment.

The same process as in a case of the AE **112** and the BHE **171** is also performed in a checking process of communication circumstances of the line **922** connecting the AE **112** to the BHE **172**. In addition, the same process is also performed in a communication checking process of the line **970** connecting the BHE **171** to the BHE **172**. In the former case, a transmission end and a reception end of the CCM frame are respectively the AE **112** and the BHE **172**, and the BHE **172** and the AE **112** in a reverse direction. In the latter case, a transmission end and a reception end of the CCM frame are respectively the BHE **171** and the BHE **172**. In communication in a reverse direction, a transmission end and a reception end are respectively the BHE **172** and the BHE **171**.

As described above, by periodically confirming communication circumstances in the sections connecting the AEs **111** to **113** to the BHEs **171** and **172** respectively, it is possible to check continuity of communication in each communication section. In a case where delivery of the CCM frame is not confirmed (normal reception (an arrival time point and an arrival interval expected in normal operation) of the CCM frame cannot be confirmed), it is considered that some sort of abnormality occurs in a line on the communication path or the relay equipment in a section of transmission and reception of the CCM frame and a communication direction thereof. This abnormality indicates, inmost cases, an increase in processed loads in the relay equipment due to traffic concentration, an abnormal operation (or break-down) of a communication function of the relay equipment, or abnormality (disconnection of the optical fiber or poor connection state/contact between the relay equipment interface and the line) of a communication line connecting relay equipments to one another. Therefore, it is necessary to take a measure (path switching) for securing a path which can perform communication in a step in which transmission abnormality of the CCM frame is confirmed.

FIG. **3** is a communication path configuration diagram illustrating a path switching method in a case where connectivity is not confirmed in the communication circumstances checking process described in FIG. **2**.

In this figure, a case is assumed in which a path failure **300** influences both the line from the AE **111** to the BHE **171** and the line in the reverse direction. Generally, a plurality of communication media (for example, there is a cable using a copper line or an optical fiber) in which communication directions are different. Therefore, in a physically abnormal state such as line disconnection, communication in both directions is influenced. In addition, if the path failure **300** is congestion (a rapid increase in signal process load) in the relay equipment (not shown) or equipment break-down, it also disrupts the communication in both directions.

Due to the path failure **300**, transmission and reception of CCM frames **9211** and **9212** cannot be performed between the AE **112** and the BHE **171**. The path failure **300** can be detected from the fact that periodical reception of the CCM frame which is transmitted from the BHE **171** stops in the AE **112**. In the BHE **171**, the path failure is detected in the same

manner based on a phenomenon in which the CCM frame received from the AE **112** stops. Through this detection, both the AE **112** and the BHE **171** determine that continuous communication in the path **921** is difficult. As a result, the equipments **112** and **171** of both ends start switching to replacement paths in each communication direction.

When the AE **112** detects the path failure **300**, the AE recognizes the danger in which a signal to be received thereby does not arrive. Then, the AE **112** requests the BHE **172** to relay communication with the BHE **171** by using a replacement system path (accurately, a part thereof) **922** which is set in advance. Here, a switching request frame **20001** is used. A configuration example of the switching request frame **20001** will be described in detail with reference to FIG. **29**. When the request is received, the BHE **172** requests the BHE **171** to switch a transfer path which is directed to the AE (here, the AE **112**). That is, a change in signal distribution settings is requested so as to send information directed to the AE **112** to the BHE **172** using the standby path **970**. A request signal (transfer request frame) **20002** used here is a control frame different from the CCM frame **10000**. A configuration example of the transfer request frame **20002** will be described in detail with reference to FIG. **29**.

FIG. **4** is a communication path configuration diagram illustrating a standby system path configuration method in a case where continuity is not confirmed in the communication circumstances checking process described in FIG. **2**. As described in FIG. **2**, a path configuration example of a case where an abnormal state (or an abnormal operation) at the time of delivery of the CCM frame **10000** is detected is shown. With reference to this figure, a description will be made of a communication path configuration method in a state in which the path failure **300** occurs in any location on the communication path **921**. This figure shows a replacement system (standby system) path in which a signal output from the AE **112** arrives at the BHE **171** via the BHE **172**, as a communication path after the switching.

A feature different from the existing switching method (for example, PTL **1** or ITU-T recommendation G.**8031**) lies in that the BHE **172** is a relay point of the switching request signal and communication after a path is changed. In other words, the tree type communication network in which the BHE **172** is a top forms a sub-tree when viewed from the BHE **171**, and further has a configuration in which the BHE **171** is added in addition to the CREs **211** and **221** as high rank equipment of the BHE **172** when viewed from the BHE **172**. This feature is derived from a configuration in which (1) the BHEs **171** and **172** are communication relay (collection) equipment having an equivalent function, and (2) all the AEs **111** to **113** are connected to the BHEs **171** and **172** in advance via paths which are independent from one another. From the feature of (1), by changing the connection relationship between the BHEs **171** and **172**, the AEs **111** to **113** can come and go in a single hierarchical tree. Further, the communication path between the BHEs is used for data communication as a bypass path, and thereby a form of the communication network is changed to a multi-hierarchical tree of two or more hierarchies so as to continuously perform communication. From the feature of (2), when a path change which depends on a communication network building plan is needed, it is possible to secure a communication path having an equivalent performance without labors such as installation of lines or movement of equipment. Further, an existing protection switching technique mainly uses a method in which an operation system and a standby system (switched destination) are set in advance for each communication unit (for example, "connection" or "path") as indicated by 1+1 or 1:1 (generally, N+M type or N:M type (a method of preparing for M standby paths in order to protect N items of communication)), and, if each item of communication is to be more reliably protected, communication network resources which are preliminarily necessary increase to that extent, whereas, in the present embodiment, communication is collected in the BHEs **171** and **172**, the standby path **970** connecting between the BHEs is shared as a standby path, and thereby it is not necessary to secure a large number of network resources. In addition, since there is a low probability that a plurality of path failures may occur, a part of the communication path **970** is shared by all the AEs **111** to **113**, and thereby it is possible to effectively use the resources. In the existing technique, only a single communication unit is protected for a single standby line (the number of settings), but the standby path **970** can be assigned to all items of communication in the configuration of the relay network **10**. The cost-effectiveness thereof is high. The relay network **10** has a configuration in which one-to-multi connection having the AEs **111** to **113** as tops and one-to-multi communication having the BHE **171** or the BHE **172** as a top overlap each other, and, in the protection switching process, the BHEs **171** and **172** are interconnection points between the individual paths **911**, **912**, **921**, **922**, **931** and **932** and the sharing path **970**. Generally, when the number of accommodated items of communication is taken into consideration, the BHEs **171** and **172** are higher in a process performance of the communication equipment than the AEs **111** to **113**. In most cases, the BHE employs a configuration of equipment itself with the higher reliability than the AE. Further, a large capacity line is easily to be used for the standby path **970** between the BHEs, and, since traffics do not flow into the standby path **970** in a normal operation, it is easy to cope with the emergency.

1-2. Outline Sequence

FIG. **5** is a sequence diagram illustrating a series of processes related to switching paths passing through the AE **112**, the BHE **172** and BHE **172** in the network configuration diagram of FIG. **3**.

In a normal operation state, the AE **112** receives data communication from the BHE **171**, and periodically receives the CCM frame **10000** in order to monitor communication circumstances of the corresponding communication path **921** (**10000-1**, **10000-2**, and **10000-*k***). When the CCM frame **10000** is normally received, the AE **112** records a time point when the CCM frame is received, and resets a timer for measuring an arrival time interval. This figure shows a situation in which the failure **300** occurs in the communication path **921** in a step in which the CCM frames **10000** are received up to the CCM frame **10000-*k***.

The time point recorded in the AE **112** is a time point when the CCM frame **10000-*k*** is received (S**101**). Successively, in a case where the next CCM frame is not received until a specific time (the set time depends on a request by a carrier or a set value in equipment, and is, for example, 3.5 times or the like more than the arrival time interval of the CCM frame) has elapsed (S**102**), the AE **112** determines that some sort of failures occur in the path **921**. More accurately, it is determined that some sort of trouble occurs in downward communication (communication from the BHE **171** to the AE **112**) using the path **921** (S**103**).

Next, the AE **112** sends a communication path switching request **20001** to the BHE **172** using the communication path **922** with the BHE **172** which does not recognize the abnormality on the communication path (S**104**). An example is shown in which a plurality of frames **20001** are sent as the switching request frame in order to prevent notification failure due to a bit error on the communication path **922** or a

signal/frame loss. This figure shows a state in which **20001-1**, **20001-2**, and frames subsequent thereto are sent. At the same time as step **S604**, the AE **112** stops (waits) a user data frame process for a specific time. This is because the AE **112** waits until a series of processes related to the path switching such as update of a path table are completed in the BHE **172** (and the BHE **171**) which are new reception equipment of a signal sent from the AE **112**, and data loss is prevented from being generated during the waiting time. In order to manage this waiting time, the switching request frame **20001** starts to be sent, and, at the same time, a waiting timer starts to be counted (**S105**). In addition, when a counted value (waiting duration) of the timer reaches a specific value (**S106**), transmission of the switching request frame **20001** finishes, and user data frames accumulated in the AE **112** are resumed to be sent (**S107**). In the sequence of this figure, a configuration change of a table in the BHE **172** is requested. This process will be described later in detail (after FIG. **31**).

FIG. **6** is a sequence diagram illustrating a flow of a path switching process using a switching operation example different from FIG. **5**, when failures occur in a communication path between the AE **112** and the BHE **171** in the network configuration diagram of FIG. **3**.

The sequence of this figure is the same as that in FIG. **5** up to the step of sending the path switching request frame **20001** to the BHE **172**. Therefore, description of steps **S101** to **S104** will be omitted.

When the switching request frame **20001** (**20001-1**, **20001-2**, and subsequent frames) is received from the AE **112**, the BHE **172** changes a path set therein so as to set a communication path from the BHE **172** to the AE **112**. Along with the path information update process, the BHE **171** is notified of a transfer request frame **20002**, and thus the BHE **171** is requested to transfer a signal directed to the AE **112** to the BHE **172**, and a path change is requested such that a reception path of an uplink signal from the AE **112** is set to the standby path **970** (FIG. **3**). When a specific time has elapsed after the transfer request frame **20002** starts to be sent or an ACK signal (not shown in this figure) for the transfer request frame **20002** from the BHE **171** is received, it is regarded that a transfer setting change process in the BHE **171** is completed. The BHE **172** confirms that the update of path information therein is completed, and sends an ACK signal **30000** for notifying of the transfer preparation completion to the AE **112** using completion of the process in the BHE **172** and the BHE **171** as a trigger. This figure shows a state in which the ACK **30000** is also transmitted in multiple times in preparation for any failures on the path **922** (**30000-1**, **30000-2**).

When the ACK signal **30000** is confirmed, the AE **112** changes a sending destination from the path **921** to the path **922**, and starts communication directed to the core networks **210** and **220** via the BHE **172** (**S107**). A process after the ACK **30000** is confirmed is the same as in FIG. **5**. A change in the table configuration inside the BHE **172** will be described later in detail (after FIG. **31**).

FIG. **7** is a sequence diagram illustrating a flow of processes in a case where a path switching control signal using a standby communication path between the BHE **171** and the BHE **172** in the sequence (a case of using the ACK signal) of FIG. **6** is transmitted and received.

First, the BHE **172** receives the switching request frame **20001** which is transmitted by the AE **112**, following step **S104** of FIG. **6**. Using this as a trigger, the BHE **172** recognizes that a certain problem occurs which impedes continuous communication between the AE **112** and the BHE **171**. Although the AE **112** transmits a plurality of switching request frames **20001** (**20001-1** and **20001-2**) for signal redundancy, path setting tables (a transfer table and a path table) in the SHE **172** are changed in the step (**S301**) in which the BHE **172** normally receives the frames. In other words, the standby path **922** which is not used in a normal operation becomes valid as a main signal path, and simultaneously a communication path directed to the AE **112** is set using the standby path **970** which connects the BHE **171** to the BHE **172** (**S302**). In addition, at the same time, a communication path is changed such that a transmission path is set to the standby path **970** in relation to an uplink signal from the AE **112** (**S302**).

For example, the BHE **172** has a BHE transfer table and/or an inter-BHE path table as described later, correlates an input communication path with an output communication path, and further stores active and standby identification information or failure identification information in advance in each table. In addition, when arrival of the path switching request frame is recognized, the BHE **172** sets a flag of the active and standby identification information or the failure identification information in standby system path information which is set in the BHE transfer table and/or the inter-BHE path table thereof in advance, so as to make an entry of the intercommunication path valid. The BHE **172** can perform path switching on a targeted flow by referring to the BHE transfer table and/or the inter-BHE path table.

In confirming normal reception in step **S301**, for example, normal reception may be recognized at a time point when a predetermined number of switching request frames **20001** are received, or a method may be used in which, after the switching request frame **20001** is received once, a confirmation frame is transmitted to the AE **112**, and the switching request from the AE **112** is determined as being valid at a time point when reception of a reply (reconfirmation) frame for the confirmation frame from the AE **112** is confirmed.

A path setting in the self equipment is changed after the switching request frame **20001** is confirmed, and a transfer request frame **20002** for accommodating communication from the BHE **171** to the AE **112** in the standby path **970** is transmitted to the BHE **171**. In addition, the transfer request frame **20002** is transmitted in multiple times in order to increase failure resistance (**20002-1** and **20002-2**). At this time, along with the start of transmission of the transfer request frame **20002**, a timer for waiting for completion of a transmission setting to the standby path in the BHE **171** is activated (**S304**). Ina step (**S305**) in which it is confirmed that a specific time has elapsed using the timer, the transfer request frame **20002** stops being transmitted, and the ACK signal **30000** for notifying of completion of preparation for the standby paths **922** and **970** is sent to the AE **112**. An operation after the notification of the ACK **30000** is sent is the same as in FIG. **6**.

In the same manner, after step **A104** of FIG. **5**, the same processes as in FIG. **7** (**S301** to **S305** etc.) may be performed.

FIG. **8** is a sequence diagram illustrating a flow of processes different from FIG. **7** in a case where a path switching control signal using a standby communication path between the BHE **171** and the BHE **172** in the sequence (a case of using the ACK signal) of FIG. **6** is transmitted and received.

Processes from the transmission start of the switching request frame **20001** from the AE **112** until transmission of the transfer request frame **20002** starts in the BHE **171** are the same as in FIG. **7**. Therefore, description up to step **S303** in this figure will be omitted.

When the transfer request frames **20002** (**20002-1**, **20002-2**, and the subsequent same frames) are received from the BHE **172**, the BHE **171** changes path settings therein so as to set communication paths for a downlink signal directed to the

AE **112** using the standby communication path **970** from the BHE **171** to the BHE **172**, and for an uplink signal which has the AE **112** as a transmission source. After the transfer request frame **20002** is normally received, in a step in which the path setting in the self equipment is completed, an ACK signal **40000** for notifying of the transfer preparation completion is sent to the BHE **172**. This figure shows a state in which the ACK **40000** is also transmitted in multiple times in preparation for any failure on the path **970** (**40000-1** and **40000-2**). As a method of conforming normal reception of the transfer request frame **20002**, for example, normal reception may be recognized at a time point when a predetermined number of switching request frames **20001** are received, or a method may be used in which, after the switching request frame **20001** is received once, a confirmation frame is transmitted to the AE **112**, and the switching request from the AE **112** is determined as being valid at a time point when reception of a reply (reconfirmation) frame for the confirmation frame from the Ad **112** is confirmed.

After the ACK signal **40000** is confirmed, the BHE **172** transmits the ACK frame **30000** for notifying of completion of preparation for the standby system paths **922** and **970** to the AE **112** via the path **922**. A process after the AE **112** confirms the ACK **30000** is the same as in FIGS. **5** and **7**.

In the same manner, after step A**104** of FIG. **5**, the same processes as in FIG. **8** (S**301** to S**303** and S**401** etc.) may be performed.

FIG. **9** is a sequence diagram illustrating changing procedures of the path setting table (path table) of the BHE **171** in the path switching sequence shown in FIGS. **5** to **8**. This figure shows path setting procedures in the opposite edge equipment BHE **171** when the AE **112** is used as trigger equipment (that is, assuming that the AE **112** detects failures) for performing a series of path switching processes.

The process procedures from steps S**104** to S**303** are processes common to FIGS. **5** to **8**, and thus description thereof will be omitted. In addition, the AE **112** may change a transmission path of an uplink signal to the standby system path **922** at a time point when the path switching request frame **20001** is sent to the BHE **172** (S**107-1**). When this path changing is performed, specifically, contents described in a transfer table (FIG. **10**: **1110**) and a management table (FIG. **10**: **1310**) are changed.

When the transfer request frames **20002** (**20002-1** and **20002-2**) are normally received from the BHE **172**, the BHE **171** changes a path for receiving an uplink signal from the AE **112** which is a corresponding access line side edge equipment, from the active system path **921** to the standby path **970** between the BHEs (S**501**). Further, in relation to a downlink signal which is transferred from the BHE **171** using the path **921**, a transmission path is changed to the standby paths **970** and **922** passing through the BHE **172** (S**502**). The path changing which is necessary in the BHE **171** is transferring a downlink signal directed to the AE **112** received from the core networks **210** and **220**, to the standby path **970**. A relay process in the BHE **171** is performed using the transfer table held in the BHE **171**.

For example, the BHE **171** has a BHE transfer table and/or an inter-BHE path table as described later, correlates an input communication path with an output communication path, and further stores active and standby identification information or failure identification information in advance in each table. In addition, when arrival of the path switching request frame is recognized, the BHE **171** sets a flag of the active and standby identification information or the failure identification information in standby system path information which is set in the BHE transfer table and/or the inter-BHE path table thereof in advance, so as to make an entry of the intercommunication path valid. The BHE **171** can perform path switching on a targeted flow by referring to the BHE transfer table and/or the inter-BHE path table.

When the above-described processes are completed, entire communication (uplink/downlink signal process) between the AE **112** and the BHE **171** which has been performed using the active system path **921** before the failure **300** occurred is performed via the BHE **172**, thereby securing communication between the AE **112** and the BHE **171**. The AE **112** resumes sending of an uplink signal when the sending timer count is completed as shown in FIG. **5** or the ACK is received as shown in FIGS. **6** to **8** (S**107-2**).

2. Edge Equipment AE

2-1. Configuration of AE

FIG. **10** shows a block configuration example of the user side edge equipment AE of the relay network **10** accommodating the access lines. Functional configurations of the AEs **111**, **112** and **121** are approximately the same. Therefore, in this figure, a representative configuration example of these AEs will be described targeting the AE **112**.

The AE **112** includes a line card **2000** (hereinafter, abbreviated to an LC in some cases; the LC is also referred to as an interface card), a switching unit **3000**, and an equipment controller **1000** (hereinafter, abbreviated to a CTR in some cases). In a general configuration of the communication equipment, a plurality of LCs **2000** are accommodated, and the respective LCs **2000** are connected to one another via the switching unit **3000** (or in a connection form using direct data exchange paths between the LCs). The switching unit **3000** may be replaced with a direct connection path between the LCs. In addition, generally, there are cases where the switching unit **3000**, the CTR **1000**, and the LC employ a redundant configuration in which a standby system block having equivalent functions is provided in preparation for equipment breakdown. In addition, the features of the present invention and the present embodiment are not influenced by whether or not there is a redundant configuration inside the equipment. For this reason, a redundant configuration method is not shown in this figure. Of course, even introduction of the redundant configuration does not influence implementation of the present invention and the present embodiment, and effects expected by the present invention and the present embodiment do not vary.

Hereinafter, each function will be described along a flow of a signal input to the AE **112**.

First, user data (hereinafter, also referred to as a main signal) is input to a line input and output unit **2100** (hereinafter, abbreviated to an LIO unit) of the LC **2000** via the access line **60**. The LIFs **2110**, **2120** and **2130** are interfaces (LIFs) for accommodating lines. In this configuration, it is assumed that the number of NLIF interfaces are provided. When the LIF confirms that the user data is input, the user data is transferred to an input buffer **2210**. The input buffer **2210** is one of functions of an input signal processing unit **2200**, and temporarily holds an input signal until the signal is terminated or a transfer process thereof is completed. The LIFs **2110** to **2130** include an optical signal transmission and reception module or an electrical line interface, recognize a reception start position (or a reception start time point) of a signal, and extract the signal for each specific cycle in a case of a synchronous line and with the packet/frame units in a case of a packet/frame communication line. A signal stored in the input buffer is a signal extracted through the above-described process in the LIFs **2110** to **2130**, and holds formed information for each predefined unit.

Next, the input signal processing unit **2200** will be described. Here, the description will be made assuming that a form of a received signal is a frame form. Through the above-described process, header information including information (frame control information) related to a transfer process of the information such as a destination identifier and a transmission source identifier of the received information, and payload information including the information itself are stored in the input buffer. After the information is stored, the frame is divided into a header part and a payload part.

First, a header extraction unit **2250** reads the header part from the input buffer **2210** and transfers the header information to a header analysis unit **2260**. The header analysis unit **2260** refers to the received header information, confirms a destination of the frame, and confirms path information in order to send the frame from an appropriate output line. In addition thereto, it is checked whether or not appending, conversion, and deletion of the header information are necessary. In a case where the input frame is an MPLS frame, there are cases where an MPLS label which is appended to the input frame is different from an MPLS label to be appended at the time of output. Further, before and after passing through the AE **112**, a case where a process priority of the information, a value of Time To Live (TTL), or the like is required to be updated is also included in the header information conversion process. This operation of the header information is performed in a header processing unit **2270**. After the header information of an output frame is fixed through the above-described process, the header information is transferred to a frame generation unit **2230**. Here, the header information is stored in a frame generation buffer **2231**.

On the other hand, in the payload part (a main body of the received information) a payload extraction unit **2220** is extracted from the input buffer **2210**. Since, in a typical frame configuration, a header part and a payload part are continuously located, the header extraction unit completes reading of the header, and, then, the payload extraction unit confirms an information start position and starts reading. For this, the payload extraction unit **2220** also has a header identifying function, or the payload extraction unit **2220** is notified of a payload start position from the header extraction unit **2250**. The configuration can be realized by either method, and, here, the former configuration is assumed (the head identifying function in the payload extraction unit **2220** is not shown; detailed description of the function is omitted). The payload information is transferred to the frame generation unit **2230** so as to form an output frame in combination with corresponding header information. A difference between a process time from header extraction to header configuration completion and an arrival time to the frame generation unit **2230** from the payload extraction unit is absorbed by the frame generation buffer **2231**. In other words, a side which arrives earlier waits until the header information and the payload (information main body) are combined in the frame generation buffer **2231** and thus a frame is formed. After an output frame of the information is generated, the output frame is moved to an output buffer **2240**. The output buffer **2240** provides a queue for a plurality of frames waiting for output to the switching unit **3000**. A reading control unit **2280** is provided so as to perform a process such as a priority output of a frame in relation to output to the switching unit **3000** from the queue. Information which is a basis of reading control in the reading control unit **2280** is based on a header processing result of each frame accumulated in the output buffer. In this figure, the header processing unit **2270** gives the information to the reading control unit **2280**.

The switching unit **3000** generally secures a sufficient capacity for the number of input frames (input data amount) from each LC **2000** (and **2000-2**). The switching unit selects an appropriate LC **2000** based on destination information in relation to a frame received from an input signal processing section **2200** and transfers the frame to an output signal processing section **2400** of the LC **2000**. A correspondence relationship between the destination information and the transmission destination LC is determined by a path control unit **1100** and a transfer table **1110**. In this figure, since the whole or some of the path information can be shared by the path control unit **1100** and the switching unit **3000**, a control line **3001** is shown. Alternatively, as another method, a method may be used in which, since the switching unit **3000** has only to know an identifier of a transmission destination LC (inside the switching unit **3000**) of a received frame, the header processing unit **2270** inserts the identifier into the frame header in advance. In this case, since the information is valid information only inside the equipment, the identifier is inserted into a region which is generally called an equipment inner header in order to be appended to the outside of the header information, for example. The equipment inner header is deleted in advance when the frame is sent from the LIO (**2100**) to the outside. A location for deletion is inside the output signal processing section **2400** or the LIO (**2100**). In the present embodiment, although a method of deleting an inner header in the LIO (**2100**) is assumed in a case of appending the inner header, the present invention and the present embodiment can be implemented in either method.

The output signal processing section **2400** plays a role of making a frame which is received from the switching unit **3000**, sent from an appropriate LIF which is directed to a destination of the frame. In a step in which a frame is received from the switching unit **3000**, the LC **2000** including a sending interface of the frame is selected, but an output interface is not specified yet. The output signal processing section **2400** determines the output interface.

Timing when the output signal processing section **2400** receives an output frame from the switching unit **3000** is generally indefinite (cannot be controlled by the output signal processing section **2400** side). Therefore, there is provided a buffer **2410** which temporarily accumulates a frame which is received from the switching unit **3000** via a switch interface part of the output frame from the buffer **2410**, and determines an interface (one of the number of NLIF interfaces indicated by the reference numerals **2110** to **2130**) which will send the frame. This interface may be indicated by only an identifier of a physical line or may be identified through combination of both identifiers of a physical line and a logical line. In a case of an Ethernet (registered trademark) frame or an MPLS frame, a plurality of VLAN tags or MPLS labels may be often inserted into a frame header. In this case, there is a probability that transmission of a forward frame may be impossible unless there is an identifier of the logical line even if only the physical line is assigned. For this reason, the physical/logical line identifiers are sent in a state of maintaining a frame form stored in the buffer **2410** as an output frame except for an identifier stored in the above-described inner header (generally, information which can be identified by other communication equipments). An output port is determined based on the transfer table **1110** of the path control unit **1100**. In the present embodiment, since information included in the transfer table **1110** can be shared by the output port search unit **2420** and the path control unit **1100**, a control line **2421** is shown. As described above, an output port may be designated in the method of using the equipment inner header. In this case, the control line **2421** is not necessary. The header processing unit

2270 inserts an output port identifier into the inner header by referring to the transfer table 1110, and the output port search unit 2420 stores the frame in a frame queue 2430 which is provided for each destination port by referring to the identifier.

A reading control unit 2460 has a function of finally determining timing when a frame is sent from the AE 112. A reading control method includes changing order of frames to be processed due to a priority output based on the header information of the frame, congestion on a path in output destination lines 4100 to 4300 corresponding to the frame queue 2430, traffic concentration on some output lines inside the frame queue 2430, or the like. Information which is a basis of the reading control in the reading control unit 2280 is based on monitoring of a state of the frame queue 2430 as well as the frame header, and state monitoring with the failure monitoring unit 1400 using the control line. A frame which is instructed to be output by the reading control unit 2460 is transferred from the frame queue 2430 to an output port distribution unit 2440. The output port distribution unit 2440 transfers the frame to a predetermined line interface LIF (any one of 2110 to 2130 in this configuration example) according to the line identifier inserted into the frame header. The reason why the output port distribution unit 2440 is provided on the rear stage of the frame queue 2430 is that, for example, in a case where a communication network employing a Line Aggregation (LAG) technique performs large capacity communication by linking a plurality of physical lines, it is necessary to practically select a line for sending each frame, and a frame copying process is necessary to transmit frames on all the lines in a case of a multicast frame. Since an output frame generated according to header information of an input frame is stored in the frame queue 2430, a relationship of the number of frames between the input frame and the output frame is one to one. The reading control unit 2430 performs sending/waiting instruction based on the frame header information and the payload information. Therefore, the output port distribution unit 2440 has a function of finally specifying a sending line.

As shown in FIGS. 2 and 3, if a use path is to be switched when path failures occur, the AE 112 is required to register two or more sending destinations of frames in the transfer table regardless of whether an output port is determined by 2420 or the header processing unit 2270. Further, a priority is given to the line group, and thereby to which line a frame is preferentially output (that is, which line is used as an active system or a standby system) is set. The failure monitoring unit 1400 determines a normal state or an abnormal state, and the output port distribution unit 2440 distributes an output line according to the determination.

Process procedures in the delay control unit are as follows. When the AE 112 receives a CCM frame from the BHE 171, the CCM frame is processed according to the above-described procedures. Since the CCM frame is the AE 112, if the header analysis unit 2260 detects that the CCM frame is directed to the self equipment, an operation of the header information which is a subsequent process is not necessary. The header analysis unit 2260 notifies the failure monitoring unit 1400 of an arrival time and an arrival interval of the CCM frame via the control line. The failure monitoring unit 1400 checks the notified communication circumstances of the CCM frame and determines whether or not the circumstances are in an abnormal state. The determination method depends on implementation much, and, for example, there is a method in which it is determined that failures occurs on a monitoring target path if a CCM frame is not normally received over 3.5 times more than the CCM frame transmission cycle as described in the ITU-T or IEEE standard regulations. When the path failures are detected, the failure monitoring unit 1400 instructs the frame generation unit 2230 to generate a switching request frame. This switching request frame is a frame which is sent to the BHE 172. The switching request frame is generated, is then promptly stored in the output buffer 2240, and is read as a high priority frame in response to an instruction to the reading control unit 2280 from the failure monitoring unit 1400. The frame which is stored in the buffer 2410 via the interfaces (IF-I (2310) and IF-O (2320)) of the switch interface (SIO) unit is read as a high priority frame in response to an instruction from the failure monitoring unit 1400 or according to inner header information appended to the frame, and is promptly transferred to the frame queue 2430. Further, the frame is output from the reading control unit 2460 of the frame queue 2430 as a high priority frame, and is sent to a line directed to the BHE 172 by the output port distribution unit 2440. The failure monitoring unit 1400 is required to record the path in which the failures occur. In this configuration example, the failure monitoring unit 1400 can also refer to the transfer table 1110 using the control line connecting the failure monitoring unit 1400 to the path control unit 1100. Since this mutual reference is used, the transfer table 1110 includes a field indicating (identifying an operation path) failure circumstances (path use circumstances) in addition to the path distribution information (FIG. 11). Of course, a method may be employed in which the failure monitoring unit 1400 has a path list independent from the transfer table, and failure circumstances are recorded in this list.

FIG. 11 shows a table configuration example of the transfer table 1110 of FIG. 10. This table 1110 correlates an input path of a signal with an output path thereof. The table 1110 includes a parameter 1116 indicating whether or not failures occur in each registered path, and a line priority 1115 which is used to select a use line in a case where a plurality of lines can be used. The line priority field 1115 is indexes (one thereof) for giving a priority to a communication line which may possibly be a transmission destination when the AE 112 processes a received signal. This table further includes a line type field 1119, and it is determined whether a path via which a signal is received and a route to which the signal is output at each time point are of active system or of standby system on the basis of the field.

The AE 112 processes the received signal (assuming a packet format in the present embodiment) using the table of FIG. 11A. Specifically, a "flow" formed by a series of packet groups and a path through which the flow should pass are identified. For this reason, identifiers (route ID) 1111 of the physical lines 4100 to 4300 or the physical interfaces 2110 to 2130 for receiving a signal and an identifier (a flow ID) 1112 for a signal (logical line) multiplexed on a corresponding line are used. An output route ID 1113 and an output flow ID 1114 are used to identify an output line corresponding thereto. In other words, a received flow and a path through which the flow passes are specified through a combination of four types of parameters.

In the present embodiment, the BHEs 171 and 172 form a pair of redundant systems in a communication path from the AE 112 to the core networks 210 and 220. Each path is indicated by an active system (Working Path/Connection; W) or a standby system (Protection Path/Connection; P). The first entry and the third entry of FIG. 11A are applied to signals which are input from the same physical line and have the same logical identifier. The first entry is an active system (high priority) and the second entry is a standby system (low priority). A failure state field 1116 indicates whether or not a communication state on a path identified by each entry is normal.

When the failure monitoring unit **1400** checks a communication state of the CCM frame and detects communication abnormality, a failure occurrence flag is recorded in the failure circumstances field **1116** on the path. Since communication in the path is required to stop along with the failure flag, a priority flag of the entry is changed when the abnormality is detected. For example, when failures occur in an output destination path of the first entry, a failure mark is written in the failure field **1116** of the entry, a priority of the path is changed to "Low", and a priority of the second entry which is a replacement path is changed to "High".

In the field in which other flags are described, for example, whether or not there is a signal using the entry, whether or not the entry is valid (based on a contract (an operation state) or a failure state), or a standby system entry number (a table address indicating the entry) corresponding to the entry is described. Particularly, it is important in the present embodiment to hold a correspondence relationship between an active system path and a standby system path. For example, in most cases, if paths are different, different identifiers are used as identifiers of logical lines. In addition, there are cases where 1+1 redundant systems (or Link Aggregation) are formed for a single flow. In these cases, it is necessary for the AE **112** to perform a transfer process by combining received signals from a plurality of paths in which identifiers of a physical line and a logical line are different from each other. Even in this special setting as such, the entries are correlated with each other in advance, and thereby it is possible to promptly search for a corresponding replacement path when failures occur.

It is important to correlate a logical line identifier (the output route ID **1113** and the output flow ID **1114**) of an output line with a physical line identifier of an interface which practically outputs a signal. In a case where the input route ID **1111** and the output route ID **1113** are IDs indicating physical lines, there is no problem, but in a case where each rout ID is a logical route ID, it is necessary to correlate the logical line with a physical line for practically sending a signal. This case is also handled using the other-flag field **1119**.

FIG. **11**(B) shows a configuration example obtained by simplifying the transfer table **1110**. In the table (B), identifiers **1117** of (typically, a plurality of) access lines **60** accommodated by the AE **112**, and identifiers **1118** which correlate the access lines **60** with an active system path (for example, the path **921** in FIGS. **1** to **4**) or a standby system path (for example, the path **922** in FIGS. **1** to **4**) in the relay network **10**, are described.

When an input signal from the access line **60** (referred to as a User Network Interface (UNI)) is transferred to a Network Interface (referred to as an NNI), the AE **112** determines whether the signal is transferred to an active system path or a standby system path by referring to this table. In order to employ the configuration of FIG. **11**(B), it is necessary to correlate the access line **60** (the path **621** in the AE **112**) with the input route/flow ID (**1117**) one to one. In addition, also in relation to the relay network **10** side interface, it is necessary to correlate the active system path **921** with the output route/flow ID (**1118**) or correlate the standby system path **922** with the output route/flow ID (**1118**) one to one. A means for this correlation is the same as that in setting the table (A). In other words, the means can be employed by designating a physical line as a route ID or performing correlation using the other flag field.

In addition, FIGS. **11**(A) and **11**(B) include both of (1) the entry (**1110**B-**1**) corresponding to upward communication in which an input signal from the access line **60** is transferred to the core networks **210** and **220** and (2) the entry (**1110**B-**2**) corresponding to downward communication in which a signal is output to the access line **60** from the relay network **10**. This table configuration may be divided for each communication direction (upward/downward) and be mounted.

FIG. **12** shows a configuration example (A) of the management table **1310** held by the path management unit **1300** forming the controller **1000** of the AE **112**. This table is a database which collects path information set in the AE **112** (the transfer table **1110** of FIG. **11** is some of the path information). The path management unit **1300** has a function of transmitting and receiving information to and from an Operating System (OpS) **10000**, and the management table **1310** plays roles of holding path setting information input from an operator, and checking communication circumstances in each path of which an operation is in progress so as to be presented to the operator (enabling the operator to monitor a state).

The configuration example (A) of this figure is a configuration example corresponding to the table entries of FIG. **11**(A). This example includes identifiers (flow IDs) **1311** of Flow-**1** and Flow-**2** which are search targets when referring to the table entry, a signal transmission direction (communication direction) **1312** for each flow, active system path setting information **1313** for the flow, a standby system path setting information **1314** for the flow, an identifier **1315** of a redundant system path (active system/standby system) which is currently used by the flow, and an other flag filed **1316**.

The active system path setting information **1313** for each flow includes an input route ID **1313-1** and an output route ID **1313-2**, and the standby system path setting information **1314** includes ID **1314-1** and an output route ID **1314-2**.

This configuration example shows that a flow identifier appended to an uplink communication signal which is received (from the access line **60**) by the AE **112** is VLAN-j, and LSP-m or LSP-n is used as a flow identifier when the received flow is transferred inside the relay network **10**. In addition, it is shown that a path which is currently used by the flow is an active system (W). This is also the same for downlink communication, and it is shown that, VLAN-q which is set to be directed to the access line **60** is applied (appended) to the signal Flow-**2** (identifier: LSP-y or LSP-w) which is received from the relay network **10** by the AE **112**, so as to be transferred. A system which is currently selected and used by Flow-**2** is an active system (W).

FIG. **13** shows another configuration example (B) of the management table **1310** held by the path management unit **1300** forming the controller **1000** of the AE **112**. This table configuration diagram shows an example in which some of the information forming the management table **1310** is collected. It is possible to realize path management by collecting and maintaining the table configuration diagram (A) shown in FIG. **12** and the configuration example (B) of this figure in a single table, or by a method of maintaining (A) and (B) as divided tables and providing communication means which maintains the tables without contradiction to each other by referring to parameters described in the mutual tables at any time.

FIG. **13** correlates a physical line interface with header information. On the other hand, FIG. **12** correlates header information with a flow ID. In other words, the configuration (A) correlates the high rank layer information (operation administrator-oriented information such as service design-setting policy/concept) with the header information, and the configuration (B) correlates a low rank layer information (hardware information) with the header information.

The table (B) of this figure shows a correspondence relationship between the physical line interfaces **2110** to **2130** which receive a signal and a logical line which is multiplexed on the physical line **4100** and is identified using header infor-

mation such as an MPLS label in relation to each input signal (flow). At the same time, the physical line interface is correlated with a hierarchized logical line (or hierarchized flow) in which an identifier is further added to a logical line (header information indicating the logical line) and a signal is multiplexed (for example, stacking of VLAN tags of Ethernet (registered trademark) or stacking of MPLS labels) and is transferred.

The entry of the table (B) is set for each physical line interface identifier **1317** (physical IF-ID). An interface type **1318** (line type) which is different for each communication protocol is set in the entry. As the line type, for example, there are a Gigabit Ethernet (registered trademark) line (GbE), 10 GbE, POS, 10 Gbps-POS (10G-POS), and the like. Although a form in which they are directly described in the table is shown in this figure, there may be a configuration in which an identifier such as a line number is set for each line type, and the identifier is described in this table, when the table (B) is actually built. Since a single physical line **1317** can include a plurality of logical lines, the physical line **1317** includes the same identifier in the entry **1317** so as to match the number of logical lines. Further, this table records a communication direction **1319** for each logical line therein. Since paths used in an outbound path and an incoming path may be set to be different in communication between the AE **112** and the BHE **171** (**172**), it is necessary to record the communication direction **1319** for each logical line. Further, a logical path identifier **13170** for forming a logical path is included. An input route ID **13171** and an output route ID **13172** are described in the logical path identifier **13170**. In a case of a signal in which an identifier of an input signal is indicated by the input route ID **13171** when the signal passes through the physical line **1317** of the entry in the direction described in the communication direction **1319**, a series of correlation between the parameters is defined in which the output route ID **13172** is appended to the signal so as to be output from the AE **112**. Further, the system type **1398** regulates whether a communication signal expressed by a combination of the above-described parameters **1317** to **13172** is used in an active system path (W) or a standby system path (P). The system type **1398** is an item for determining a use priority of each path in a case of setting a plurality of logical paths, and, for example, in a case of two paths, identifiers for identifying the active system and the standby system are described therein. Further, in a case of setting a plurality of paths in order to protect between the AE **112** and the BHE **171** (**172**), an identifier indicating a use priority (ordering to be validated) of each path is described in the system type **1398**. In an other-information field **1399**, information of validity of the entry (whether or not the entry is invalid), a use frequency of the path, the set band in a case of setting a band assignment to each path, and the like is described.

FIG. **14** is a configuration example of the delay table **1210** held by the delay control unit **1200** of the AE **112**.

This table **1210** includes a flow ID (**1311**), a path ID (a logical line ID (**13170**)) indicating a path through which the flow passes, and a transfer waiting time (**1211**) which is to be requested for the flow. In addition, as other parameters, a line type **1318**, a communication direction **1319**, a system type **1398**, and other information(s) **1299** are included. Other parameters are information which is referred to when the transfer waiting time **1211** is determined, or information which is referred to and thereby an appropriate waiting time setting is possible. For example, the transfer waiting time **1211** is required to be set to be shorter as the line type **1318** (that is, a line speed) is faster (a transfer performance is higher) in order to reduce influence on communication. In addition, in a case where a communication direction is directed to the core networks **210** and **220** (an uplink signal), some transfer waiting time **1211** is necessary when the path is switched in the relay network **10** in the AE **112**; however, in a case of a downlink signal, the transfer waiting time **1211** in the AE **112** is regarded as a signal instantaneous interruption time which is required for the path switching process. The signal instantaneous interruption time in the latter (when a downlink signal is transferred) is used in a case of changing a process priority (a priority of a reading process from the frame queue **2430**) of a data frame which is transferred to the access line **60** from the AE **112** according to the type of data frame, before and after switching, for example.

In determining the transfer waiting time (**1211**), a count time of a timer is referred to in a case of using the transfer waiting timer when the switching process is performed as shown in FIG. **5**. The transfer waiting timer is provided in the delay control unit **1200**, and the transfer waiting time is determined by referring to a value of the timer counter when a signal passing through the path is received from the access line **60** during the path switching process. In other words, the timer counter and the transfer waiting time **1211** of the table **1210** are synchronously operated. On the other hand, in a configuration in which transfer is resumed using a reception confirmation of an ACK signal from the BHE **172** as a trigger according to the sequence shown in FIGS. **6** to **8**, a predefined maximum value is described in the transfer waiting time **1211**, and a signal of the flow is sent when transfer can be resumed. The maximum value set at this time may be determined for each flow ID **1311** (according to the type of service accommodated by the logical line **13170**). The waiting time is managed with the signal (frame) unit, and whether a frame which exceeds a transfer waiting time (maximum value) of the flow from a signal reception time is discarded or accumulated is determined depending on the type of service. In a case of confirming the ACK as in the latter case, a flag indicating whether or not transfer is possible according to reception/non-reception of an ACK is described in the other-information field **1299** and is used together with the transfer waiting time field **1211**.

FIG. **15** shows an interrelationship among the tables shown in FIGS. **11** to **14**. A role of each table, a configuration example thereof, and a use method when practically operated are the same as described with reference to FIGS. **11** to **14**, and thus repeated description will be omitted here.

2-2. Process of AE

FIG. **16** is a flowchart illustrating a flow of processes related to setting path information in the AE **112**. The operator accesses communication equipment such as the AE **112** or the BHE **171** via the OpS (**90000**) and inputs communication path settings for forming a communication network therein. In the present embodiment, the path management unit **1300** manages whole path information which is input to the AE **112**. Therefore, path setting information input from the operator and communication circumstances in each path are recorded in the database **1310** (the management table) managed by the path management unit **1300**. The operator may access the path management unit **1300** in order to check communication circumstances.

This flowchart shows a flow of processes when an initial setting of the AE **112** is performed. First, path information is input to the path management unit **1300** from the operator. The path information is held in the path management unit **1300** as the management table **1310** (F**101**). The path information which is temporarily held in the path management unit **1300** is shared by the delay control unit **1200** and the path control unit **1100** and is used to perform a process required for

each function. The path control unit **1100** holds the path information which is held by the path management unit **1300**, in a form of the transfer table **1110** in order to perform a transfer process based on a header analysis result of an input frame (FIG. **11**) (F**102**). Further, the delay control unit **1200** monitors a delay time on a communication path at any time, and records state variations such as deterioration in a communication performance or communication disconnection caused by congestion or failures on the path. In addition, a process of delaying (waiting up to sending time) sending from the AE **112** for a specific time is performed according to the type of transferred information. In order to realize it, the delay control unit **1200** holds the information of the path management unit **1300** in a form of the delay table **1210** (F**103**). In addition, the transfer table **1110** reflects the latest circumstances thereon at any time in response to a control signal from the failure monitoring unit **1400** in a case where switching of a communication path occurs or the like. The information held in the delay table **1210** is also rewritten at any time according to communication circumstances. A notification of the communication circumstances generated by each functional unit is sent to the path management unit **1300** periodically or at any time in a case where a communication state varies, so as to be reflected on the management table **1310**.

FIG. **17** is a flowchart illustrating processes related to a path monitoring frame (a CCM frame) in a header analysis unit **2260** of the AE **112**. As a frame type processed by the header analysis unit **2260**, there are a user data frame received from the access line **60**, a CCM frame received from the BHEs **171** and **172**, and an OAM frame for performing control inside the relay network **10**. Among them, this figure extracts and shows a flowchart regarding a process on the CCM frame related to the path switching process of the present embodiment.

The header analysis unit **2260** starts a header analysis process using an input of frame header information from the header extraction unit **2250** as a trigger (F**201**). After the process starts, first, the received frame header is analyzed (F**202**). In this step S**202**, information (parameter) required for the analysis process is extracted from the received frame header information, and a process method is determined inside the header analysis unit **2260** by referring to the parameter, or the path control unit **1100**, the failure monitoring unit **1400**, and the delay control unit **1200** are notified of the parameter, and a header analysis process is performed by referring to a response notification from each functional unit obtained as a result thereof or in a form according to the response notification.

Processes after step S**203** are processes related to the CCM frame. First, it is determined whether or not the received frame is a CCM frame (F**203**). If the received frame is a normal data frame which is not the CCM frame, for example, a data frame received from the BHE **171** or a data frame received from the access line **60**, a header process is performed on the normal frame, and the frame is terminated or is transferred as shown in FIG. **18** described later (F**209**). If the received frame is recognized as the CCM frame in step S**203**, the flow is moved to a process on the CCM frame.

First, it is checked whether or not the CCM frame is received from a normal path (F**204**). If the CCM frame is to be sent, equipment or an equipment interface which is a generation and transmission source thereof, and equipment or an equipment interface which is used as a reception side of the CCM frame are required to be clearly regulated before the system is operated. This setting can be confirmed in the failure monitoring unit **1400** and the path control unit **1100** via the path management unit **1300**. If the CCM frame is received from a path other than the expected paths, since the path is a path which is not set in the relay network **10** by the operator, the path is closed (F**207**), and a notification of the fact indicating that the unexpected CCM frame is received is sent to the path management unit **1300** for warning (F**208**).

If the CCM frame is received from a set (approved) path, an arrival time of the CCM frame at the AE **112** is recorded (F**205**). This time point is used to confirm a CCM frame reception interval when another CCM frame is received from the same path after a specific time has elapsed. In addition, in a case where the CCM frame can not be received for a specific time or more (for example, in a case where the path failure **300** occurs or the like), an elapsed time from a time point when the CCM frame finally arrives is referred to, and occurrence of the failure **300** is recognized using the above-described predetermined elapsed time. The failure monitoring unit **1400** and the delay control unit **1200** are notified of the arrival time recorded in step S**205** and a path ID (a physical line ID or a logical line ID) for identifying the path through which the CCM frame passes (F**206**).

FIG. **18** is a flowchart illustrating process procedures of a user data frame in the header analysis unit **2260** of the AE **112**. This figure shows the process in step F**209** of FIG. **16**.

The header information of the received frame is received from the header extraction unit **2250** (F**301**), and the information is inquired of the path control unit **1100** (F**302**). The path control unit **1100** searches the transfer table **1110** so as to check whether or not the frame is included in the entries, and check the validity of the entry when valid/invalid information of the entry is included in the other-flag field **1119** (F**303**). Here, in a case where the header information is not included in the entries of the transfer table **1110**, or the entry is invalid, a notification is sent to the header analysis unit **2260** so as to discard (delete) the received frame (F**310**).

In a case of a valid entry, the path control unit **1100** extracts both or either an output route ID and/or an output flow ID of the frame (F**304**). In addition, the output route ID (**1111**, **1112**, or **1117**) and the output flow ID (**1113**, **1114**, or **1118**) are extracted from the transfer table **1110**. Along with the search of the transfer table **1110**, the path control unit **1100** checks whether or not queuing is necessary when transfer is performed for the delay control unit **1200** (F**305**). Whether or not queuing is necessary can be known, for example, by checking a communication state of a transmission destination (output route) of the frame from the delay table **1210** and by confirming the transfer waiting time **1211** which is described when a switching process is in progress for some reason such as occurrence of failures in the path or path holding at the time of maintenance by the operator. The header processing unit **2270** is notified of information (header processing information for outputting the frame to the output route) related to the output route ID and the output flow ID extracted from the transfer table **1110** and whether or not queuing is necessary (and queuing time when the queuing is necessary) (F**307**). Process procedures of the frame information in the delay control unit **1200** in step F**306** will be described with reference to FIG. **20**.

FIG. **19** is a flowchart illustrating process procedures of the path monitoring frame (CCM frame) in the failure monitoring unit **1400** of the AE **112**.

After forming of the redundant system paths (the active system path **921** and the standby system path **922**) connecting the AE **112** to the BHE **171** and the BHE **172** is completed, communication starts between the equipments (enters an operation state). Along with the operation start, the CCM frame **10000** starts to be transmitted to the paths **921** and **922** in the upward direction and the downward direction. Each of

the AE **112** and the BHEs **171** and **172** sends a CCM, receives the CCM frame **10000** from the opposite equipment connected via the paths **921** and **922**, and monitors arrival circumstances of the CCM frame, thereby determining whether or not a communication state of the path **921** or **922** is normal. In order to monitor the arrival circumstances of the CCM frame, along with the operation start, each of equipment (here, the AE **112** as an example) activates a timer which measures waiting time until the CCM frame is received (F**401**). The timer measures a CCM frame arrival interval and is used to determine whether or not communication is normally performed based on this information.

The failure monitoring unit **1400** confirms the timer activated in step F**401** for each specific time. At this time, an elapsed time is recognized from the timer count, and it is determined whether or not the elapsed time lies within a predetermined threshold value set in advance (F**402**). This predetermined threshold value may be set to 3.5 times more than the CCM frame transmission interval (since the value may be different depending on a request when equipment is used, the value is only a set example), for example, as described above. If the elapsed time lies within the predetermined value, it is further checked whether or not CCM frame information is received from the header analysis unit **2260** (F**403**). If the CCM frame is not received, the timer count is continuously performed and arrival of the CCM frame is awaited.

If the timer count value lies within the predetermined threshold value, and the CCM frame is received, processes after step F**404** start. Based on the frame header information received from the header analysis unit **2260**, an arrival time of the CCM frame which has arrived is recorded (F**404**). The arrival time can be obtained from an arrival time interval of the CCM frame and an arrival time point of the previously received CCM frame, obtained from the timer count value. An arrival time point of the latest CCM is compared with an arrival time point difference of the CCM frame received from the same path one step before, and thereby an arrival time interval is recorded (F**405**). In addition, the arrival time interval may also be obtained from an arrival timer count value. If the arrival time interval obtained in step F**405** is deviated by a predetermined threshold value or more from a transmission and reception interval of the CCM frame in the path, set before the operation, the path management unit **1300** is notified of a warning (F**408**). The path management unit **1300** describes the warning in the management table **1310** and notifies the operator (or enables the operator to refer to). If the deviation of the arrival time is equal to or less than the predetermined threshold value, the CCM frame waiting timer activated in step F**401** is reset, and reception of the next CCM frame is awaited (F**407**).

In a case where a timer value exceeds a specific time earlier than reception of the CCM frame, the failure monitoring unit **1400** recognizes that communication failures occur in the path (F**410**). In order to send the path switching request **20001** from the AE **112** to the BHE **172**, the failure monitoring unit **1400** instructs the frame generation unit **2230** and the reading control unit **2280** or the frame generation unit **2470** and the reading control unit **2460** to generate and preferentially process the switching request frame **20001** (F**411** and F**412**). Further, when path switching is performed (for example, when switching from the active system path **921** to the standby system path **922** is performed), since update of the transfer table **1110** due to the path switching, reflection of the updated information on the switching unit **3000**, and update of the transfer table in the BHEs **171** and **172** require a specific time, the failure monitoring unit **1400** instructs the reading control unit **2280** to wait for transferring a frame to the path and notifies the delay control unit **1200** of a transfer waiting time to the path, thereby reflecting the information on the delay table **1210** (F**412**). The path management unit **1300** is notified of the path switching information and the transfer waiting time setting information at any time so as to be recorded in the management table **1310**.

FIG. **20** is a flowchart illustrating process procedures related to transfer of a received frame in the delay control unit **1200** of the AE **112**.

When received frame information is received from the header analysis unit **2260** (F**501**), a path through which the received frame passes is searched using the delay table **1210** (F**502**). Before step F**502**, an input path (a physical path ID or a logical path ID) of the frame is confirmed from the transfer table **1110**, and the delay table **1210** is searched using sending destination path information (a physical path ID or a logical path ID) or a flow ID obtained from the transfer table **1110**.

In a case where a sending destination of the received frame is under a switching process due to occurrence of failures or the like, and a frame directed to the path requires transfer waiting, the transfer waiting time **1211** is obtained from the delay table **1210** (F**503**). The reading control unit **2280** and the output timing control unit **2450** are notified of the transfer waiting time (output time point) when the frame is transferred, obtained here (F**504**). This method is a means for directly notifying the reception side LC and the transmission side LC from the delay control unit **1200**. In addition, as a method of notifying the transmission side LC of the information, there is a method of using an equipment inner header for describing frame process information inside the equipment. In this method, a sending time point of the frame is described in a part of the equipment inner header, and the output timing control unit **2450** and the reading control unit **2460** of the transmission side LC confirm the sending time and send the frame according to the inner header. In any method, the received frame can be temporarily accumulated in the buffer and be sent at a predetermined time point. In a case where there is no designation of the transfer waiting time **1211** for a transmission destination path of the received frame, a normal transfer process is performed on the frame (F**505**). In this case, the delay control unit **1200** is not required to particularly instruct each functional unit of the LC **2000**.

3. Backhaul Edge Equipment BHE

3-1. Configuration of BHE

FIG. **21** is a block configuration diagram illustrating a configuration example of ISP network/core network side edge equipment BHE of the relay network **10** which accommodates access lines. Functional configurations of the BHEs **171**, **172** and **181** are approximately the same as one another. Therefore, as a representative configuration example of these BHEs, this figure shows a functional block configuration diagram of the BHE **171**.

The BHE **171** provides a signal relay function in the relay network **10**, and further provides an interconnection function with the high rank networks (the ISP networks or the core networks) **210** and **220**. The former is common to the communication function of the AE **112** shown in FIG. **10**, and description thereof will be omitted in this figure. The latter has a function similar to the access line accommodation function of the AE **112**. As an example of the similarity, the AE **112** and other AEs accommodate a plurality of access lines in some cases. As shown in FIG. **1**, when the AE **111** accommodate the access lines **611** and **612**, and receives a signal from the inside of the relay network to the access line, the AE **111** determines to which access line the signal is transferred and distributes the signal. Similarly, when the BHEs **171** and

172 receive a signal from the relay network 10 to the high rank networks 210 and 220, the BHE determines to which high rank network the signal is transferred and distributes the signal.

There is a case where both the AE and the BHE simultaneously send a signal (packet) received from the relay network 10 to a plurality of lines accommodated in the AE and the BHE. For example, this case corresponds to a case where data for multiple users such as broadcast signals is transferred in the AE, and a case of performing simultaneous backup on a data center at a remote location from a company site or the like via the access line 60, the relay network 10, and the high rank networks 210/220 in the BHE.

As described above, processes in the BHE and the AE are approximately the same as each other with regard to a normal signal transfer process inside the relay network 10 and intercommunication between the relay network 10 and an external network (communication with the high rank networks 210/220 via the interconnection line 90, or communication with the user network via the access line 60), and thus detailed description related to the signal process will be omitted in this figure.

The BHE 171 includes an LC 6000, an SU 7000, and a CTR 5000 in the same manner as the AE 112 (FIG. 10). In a general configuration of the communication equipment, a plurality of LCs 6000 are accommodated, and the respective LCs 6000 are connected to one another via the SU 7000 (or connected in a connection form using direct data exchange among the LCs).

A configuration and a use method of a transfer table 5110 held by the BHEs 171 and 172 are also approximately the same as the configuration example of the transfer table 1110 of the AE 112 shown in FIG. 11. In the transfer table 5110, in the same manner as in the AE 112, transfer control information for performing transfer control inside the relay network 10 and intercommunication between the relay network 10 and the high rank networks 210 and 220 are held in a form of FIG. 11. The failure information 1116 shown in FIG. 11 is also used in the same manner for the transfer table 5110 of the BHEs 171 and 172. In other words, communication using the paths (paths connecting the BHE to the AEs 111 to 113) in the relay network 10 is monitored, and whether or not there are failures in each path is recorded.

A configuration and a use method of a delay table 5210 held by the BHEs 171 and 172 are also approximately the same as the configuration example of the delay table 1210 of the AE 112 shown in FIG. 14, and thus description thereof will be omitted in this figure. In the transfer table 5210, in the same manner as the delay table 1210 of the AE 112, transfer control information for performing transfer control inside the relay network 10 and intercommunication between the relay network 10 and the high rank networks 210 and 220 are held.

FIG. 22 is a table configuration diagram illustrating a configuration example of the inter-BHE path table 5510 in the functional block of the BHE 172 of FIG. 21. This table records therein information regarding the communication path 970 (also referred to as a standby path) between the BHEs shown in the network configuration diagrams of FIGS. 1 to 4.

The setting information of the standby path 970 includes path information for monitoring a path state (for transmitting and receiving a CCM frame) which is set in the path in advance and path information for mutual notification of path information between the BHEs. In addition, identification information for recognizing a flow ID (or a physical line ID and a logical line ID, or either one) which should be communicated using the standby path 970 is included in a case where failures occur in some scheduled (active system) communication paths inside the relay network 10.

A table configuration example of FIG. 22A is similar to those of the transfer table 1110 and the transfer table 5110 of the AE 112 and the BHE 172. In other words, logical (or physical) line interface identifiers 5511 for connection between the BHEs 171 and 172, (typically, a plurality of) logical paths (logical lines/flows) IDs 5512 accommodated by the interfaces 5511, and communication directions 5513 of the respective flows, are included.

The communication direction of the flow is different depending on (1) whether the flow is received from the BHE 171 or (2) the flow is sent to the BHE 171. In addition, the communication direction is different depending on (A) whether the flow is transferred from the outside (the access line 60 or the core network) to the relay network 10 or (B) a reverse direction thereto. Each flow can be identified as being of four types through this combination. In addition, in a case where the physical line interface is required to be correlated with the logical line interface, the correlation can be realized using the other-flag filed in the same manner as in the transfer table 1110 (FIG. 11) of the AE 112 (here, the same description as in FIG. 11 will be omitted).

This table further includes an input route ID 5514 and an output rout ID 5515. These input and output route IDs are parameters for identifying each flow in the BHE 172. A usage flag 5518 of control (C) indicates that the flow does not use a standby system path. In a case where this flag is rewritten to data (D), this indicates that a flow identified using a combination of the parameters 5511 to 5515 of the entry performs communication using the standby path 970 due to communication abnormality or the like of a scheduled (active system) path inside the relay network 10. One of features of the present invention and the present embodiment is to use the standby path 970 for transfer of a data signal as well as a control signal.

In this configuration example, a table configuration which makes the communication on the standby path redundant for each flow passing through the standby system path is provided. This is a means for avoiding communication failures in the standby path 970 and thus preventing deterioration in a situation. For this reason, a priority (type) 5516 for designating an active system path (Working Path; W) or a standby system path (Protection Path; P) for each flow is included. Further, among the input/output route ID settings of this figure, the parameter in the parenthesis indicates a route ID used (that is, set in the standby path 970) for connection between the BHE 172 and the BHE 171.

In the table configuration example of FIG. 22A, the following is shown in order from the top of the entry.

<1> Reception flow from the BHE 171

<2> Transmission flow to the AE 112

<3> Transmission flow to the BHE 171

<4> Reception flow from the CRE

Processes regarding these flows are as follows in order.

<1> Transfer process from the BHE 172 to the CRE

<2> Transfer process from the BHE 172 to the AE 112

<3> Transfer process of a signal which is received from the AE 112 by the BHE 172

<4> Transfer process of a signal which is received from the CRE by the BHE 172

FIG. 22(B) shows a classified table which collects a communication direction and transmission source/transfer destination of the frame for performing the above-described transfer process. The "flow" described in FIG. 22(A) indicates a flow which is accommodated in the standby path 970 in an emergency. This "flow" corresponds to a flow of which use is

necessary (Yes; Y) in determination **5110***d* regarding whether or not the standby path is used in the table of FIG. **22**(B). In other words, the entries **5110-5** and **5110-6** which do not use the standby path **970** are not required to be described in the inter-BHE path table **5110**. In order to show a process relationship between the entry of FIG. **22**(A) and the entry of FIG. **22**(B), mutual correspondence is shown using the numbers <1> to <4> in the figures. The entries indicated by the same number have the same signal path inside the relay network **10**. The table configuration example of FIG. **22**(B) is not required to be used to monitor or switch a communication path. The table configuration example is information which is referred to when forming the inter-BHE path table **5510** (FIG. **22** (A)) or referred to when the operator performs path management.

FIG. **23** shows a configuration example (A) of the management table **1310** held by the path management unit **5300** in the controller CTR **5000** of the BHE **172** (FIG. **20**). This table is a database which collects path information set in the BHE **172**, and a table configuration method of this table is approximately the same as in FIG. **12**. This table is some of information which should be held by the path management unit **5300** in the same manner as the management table in the AE **112** of FIG. **12**. Information registered in this table includes the path information for forming the inter-BHE path table **5110** shown in FIG. **21**(A).

This table includes a flow ID (**5311**), a communication direction **5312** of the flow, an active system path **5313** and a standby system path **5314** assigned to the flow, a selected system identifier **5315** indicating a system (active/standby) which is currently used by the flow, and a line type identifier **5316** indicating a usage of the flow. The parameters other than the line type identifier **5316** are the same as in the description of FIG. **12**, and description thereof will be omitted in this figure.

Either Data (D) or Control (C) is set in the line type identifier **5316** as an identifier indicating a usage of the line. "D" is set in a data communication system path inside the relay network **10**, and "C" is set in the standby system path **970**. In a normal operation, only the path indicated by "C" is used for communication of control information. The path in which "D" is set is used for transmission of a data signal (audio, broadcast, Internet content, or the like). A communication state is monitored using an OAM frame or the like in all the lines, and thus health checking for the lines is performed.

From this configuration example, for example, the flow (F-c) uses LSP-K and VLAN-W respectively as the input route ID (**5313-1**) and output route ID (**5313-2**) of Working Path (**5313**) in a case where an active system path can be used. Since the communication direction **5312** is Up, it can be seen that the flow should be transferred to the CRE **211** or **221** from the AE **112** via the BHE **172**.

This configuration example shows circumstances in which the flows identified by F-a and F-b perform communication using an active system path (W) and the flow identified by F-c uses a standby system path (P). the selected system identifier **5315** is a field updated at any time along with protection switching (including path switching based on judgment of the operator) according to circumstances of the communication path or path setting changing when a service is added/changed.

In a case where the data communication path is switched from the active system to the standby system, the selected system identifier **5315** is updated. In addition thereto, the line type identifier **5316** may be rewritten. In other words, the type of a control signal path is switched from "C" to "D", and thereby it is possible to understand path use circumstances on the management table. In the latter case, if a line used for communication in the active system path is rewritten from "D" to "C", or is rewritten to another identifier indicating occurrence of failures, an operation state is more easily checked.

In a case where failures occur in the communication path inside the relay network **10** assigned to each flow, the flow is promptly transferred to the CRE **211** or **221** via the BHE **171**. In this case, a communication path (standby system) after the path switching includes the standby path **970** (that is, a communication line for control information, connecting the BHE **171** to the BHE **172**).

In order to perform path switching to the standby path **970**, flow identifiers (input route and output route) which are required to be appended to the flow (F-c) (a header of a packet group forming the flow) are LSP-J and LSP-N described in the standby system path (**5314**). Here, LSP-N is a logical line ID for transferring the flow (packets) to the standby path **970**.

FIG. **24** shows a configuration example (B) of the management table **5310** held by the path management unit **5300** in the controller **5000** of the BHE **172**. The table configuration diagram (A) shown in FIG. **23** and the configuration example (B) of this figure may be collected and maintained in a single table, or may be maintained as divided tables and may be maintained without contradiction to each other by referring to parameters described in the mutual tables at any time, depending on a mounting condition. A specific table configuration method is the same as in the configuration example (B) of FIG. **13**, and thus description thereof will be omitted in this figure. A relationship between the table (A) of FIG. **23** and this figure (B), that is, correlation of a superordinate concept such as a service identifier with a line/flow identifier in (A), and correlation with a subordinate concept (hardware concept) such as a physical line/physical interface in (B) are the same as described with reference to FIGS. **12** and **13**.

Upon comparison with the table of FIG. **13**, in a case of mounting this table (B) in the BHE **172**, entry types registered in the table increase. In other words, a parameter for identifying the standby path **970** is added. In this configuration example, the IF type/communication direction information (**5319**) field corresponds thereto. The entry indicated by Protection Path (PP) indicates a communication path including the standby system path **970** between the BHEs.

In this configuration example, among the entries of the physical IF-ID (**5317**), the entries from PHY-**1** to PHY-**4** indicate path settings for data communication. These entries use a standby system communication path via the standby path **970** in a case where failures occur in the active system path (W) and protection switching occurs. For this reason, the entry in which Working (W) is described in the system type information (**5398**) indicates an active system path setting, and the entry in which Protection (P) is described in the same information **5398** indicates a bypass path (standby system path) via the standby path **970**.

On the other hand, a signal which is sent from the BHE **171** to the BHE **172** is a control signal for sharing operator setting information regarding each of BHE, or a data signal passing through the standby path **970** due to path switching when failures occur in a data path. In order to reliably transmit and receive the control signal in the standby path **970**, and in order to reliably accommodate data signal communication as a standby system path, the standby path **970** uses a redundancy means such as 1:1 or 1+1 protection switching or application of LAG, thereby increasing failure resistance. In this configuration example, PHY-**5** and PHY-**6** have a relationship of an active system and a standby system with each other, and, thus, even if one communication is disrupted, the other path is set to be used, thereby increasing continuity of communication.

3-2. Process of BHE

FIG. **25** is a flowchart illustrating a flow of processes related to setting path information in the BHE **172**. The processes in this figure are approximately the same as the path information setting procedures of the AE **112** shown in FIG. **15**. The operator accesses the communication equipment such as the AE **112** or the BHE **171** via the OpS (**90000**) and inputs communication path settings for forming a communication network therein. In the present embodiment, the path management unit **1300** manages whole path information input in the AE **112**. Therefore, path setting information input from the operator and communication circumstances in each path are recorded in the database **1310** (the management table) managed by the path control unit **1300**. The operator may access the path management unit **1300** in order to check communication circumstances.

The processes in steps F**701** to F**704** are the same as those in FIG. **15**, and thus description thereof will be omitted. After path information settings in the BHE **172** or **171** are completed in step F**704**, it is checked whether or not communication between the BHE and the opposite BHE **171** or **172** connected via the standby path **970** is possible, that is, path information settings in the opposite BHE are completed (F**705**). If the communication is possible, first, the BHE **172** (or **171**) notifies the opposite equipment of contents of the inter-BHE path table **5510** of the self equipment, and requests the opposite equipment (BHE) to notify of the inter-BHE path table of the equipment (F**706**). In the step in which the BHEs **172** and **171** share setting circumstances of the inter-BHE path table **5310** with each other, the path information setting process of the BHE **172** is completed. In addition, the inter-BHE path table from the opposite equipment is held by the inter-BHE path monitoring unit **5500** or the path management unit **5300** or both of them. In addition, a notification and a request of information are mutually performed in order to maintain consistency of this information by checking path information at any time even in a case where settings are changed by the operator even during an operation of the relay network **10** or a path switching process occurs from communication circumstances with the AEs **111** to **113**. In relation to this information notification, in addition to the time when a specific event occurs, information sharing is performed periodically, after a predetermined time interval is set to the maximum value and an information sharing process is completed once, and before the predetermined maximum time has elapsed.

FIG. **26** is a flowchart illustrating process procedures when a path switching request **20001** is received by the header analysis unit **6260** of the BHE **172**.

The processes in steps F**801** to F**804** and steps F**808**, F**809** and F**810** are approximately the same as the procedures of FIG. **16** which show a method of processing the CCM frame. Steps F**801** to F**804** respectively correspond to steps F**201** to F**204**, and steps F**808** to F**810** respectively correspond to steps F**207** to F**209**. Here, the figure extracts and shows processes in a case where the BHE **172** receives the path switching request frame **20001** from the AE **112**.

If, in step F**803**, the path switching request frame **20001** is confirmed, and, in step F**804**, it is confirmed that the request frame is received from a correct path, the BHE **171** is requested to perform path switching so as to use a standby path, in order to secure a communication path using the standby path **970**. Specifically, the AE **112** instructs the BHE **171** to change the transfer table so as to transfer a downlink signal directed to the AE **112** from the BHE **171** to the standby path **970**, thereby receiving the communication signal in the downward direction. This instruction uses the transfer request frame **20002** (F**805**). The transfer request frame **20002** is generated by the frame generation unit **6230**.

Further, in order to continuously perform uplink communication of the flow via the BHE **171**, the path control unit **5100** changes the path information of the transfer table **5110** so as to transfer a signal arriving from the AE **112** to the standby path **970**. In addition, the transfer table **5110** is rewritten such that a downlink signal directed to the AE **112** which is received via the BHE **171** is identified, and is transferred to the AE **112** using the path **922** (F**806**). Finally, the path control unit **5100** notifies the path management unit **5300**, the delay control unit **5200**, and the inter-BHE path monitoring unit **5500** of the updated contents of the transfer table **5110** (F**807**). The functional blocks which have been notified respectively perform reflection on the management table **5310**, update of the delay monitoring path setting in the delay table **5210**, and update of the use circumstances of the standby path **970** in the BHE path table **5510** (addition of a flow entry to the inter-BHE path table for accommodating a new flow).

FIG. **27** is a flowchart illustrating procedures of the path switching process when a path switching request frame is received by the CTR **5000** of the BHE **172**. This figure shows respective processes by the path control unit **5100**, the inter-BHE path monitoring unit **5500**, the failure monitoring unit **5400**, and the frame generation unit (either **6230** or **6470**; although description is made assuming the latter in this figure, realization is possible even using either functional block).

The path control unit **5100** is notified by the header analysis unit **6260** so as to recognize that the path switching request frame **20001** arrives (F**901**). Since standby system path information is set in the transfer table **5110** of the path control unit **5100** in advance, a failure flag is promptly set in the transfer table **5110** (a flag of the active system path is set to "1", or an invalid flag of the entry is set in the other-information filed) so as to make the entry of the standby system path valid. Through the above-described processes, path switching is performed for the flow (F**902**). In addition, a path called the standby system path here indicates the standby path **970** between the BHEs. If the path switching is completed, the path control unit **5300** notifies the inter-BHE path monitoring unit **5500** and the failure monitoring unit **5400** of the use start of the standby path **970** by using control signals F**903** and F**904**, respectively. When the inter-BHE path monitoring unit **5500** is notified, the inter-BHE path monitoring unit adds an entry of the flow which is a switching target (a transfer target to the BHE **171**) to the inter-BHE path table **5510** (F**907**). The failure monitoring unit **5400** instructs the frame generation unit **6470** to generate the transfer request frame **20002** directed to the BHE **171** in response to the notification. Further, the reading control unit **6280** (or **6460**) is instructed to promptly read the transfer request frame (F**908**). In addition, in a case where the prompt reading instruction of the transfer request frame is sent to the reading control unit using inner header information, the process in step F**908** is regarded as being included in a process (F**909**) of the frame generation unit **6470**. Further, the notification F**905** sent from the failure monitoring unit **5200** to the frame generation unit **6470** may be performed from the inter-BHE path monitoring unit **5500** to the frame generation unit **6470** (F**906**). When an instruction for generation of the transfer request frame is received from the delay monitoring unit **5200** or the inter-BHE path monitoring unit **5500**, the frame generation unit **6470** forms a control frame **20002** directed to the BHE **171** (F**909**) in response thereto. The transfer request frame **20002** formed here is promptly transferred to the frame queue **6430**, and is delivered via any one of the LIFs **6110** to **6130** (F**910**).

The path control unit **5100** notifies the path management unit **5300** and the delay control unit **5200** of the path change to the standby path **970** (F**920**). This notification F**920** is necessary for the delay control unit **5200** to be informed of the path setting circumstances in order to set signal transmission and reception between the AE **112** and the BHE **171** as a new monitoring target, and for the delay control unit **5200** to recognize the communication path **922** with the AE **122** and the standby path **9709** as target paths.

In step F**921**, it is checked whether or not setting of a standby system communication path passing through the BHE **172** is completed. As a checking method at this time, as shown in FIGS. **7** and **8**, there are a method of waiting for a specific time after the BHE **171** is notified of the transfer request and a method of checking whether or not a notification (ACK) of a process completion is received from the BHE **171**. Although depending on a mounting design of communication equipment and a communication network, either method may be used to implement the present invention and the present embodiment. When the setting of the standby system communication path (update of the settings of various tables for interconnection between the path **922** and the standby path **970**) is completed, communication between the AE **112** and the BHE **171** is resumed using the paths (F**922**).

4. Frame Configuration

FIG. **28** is a signal configuration diagram illustrating a configuration example of the frame used for communication between the BHE **172** and the BHE **171** when using the standby path **970**. There are two methods as methods of performing communication between the BHEs using the standby path **970**. One method is to set an individual flow identifier (as described above, a VLAN tag or an MPLS label may be used as the identifier) for each flow in the standby path **970** and to convert the identifier when the BHE **172** relays communication between the BHE **171** and the AE **112** (that is, a method of performing an interconnection process), and the other method is to set a common identifier for a plurality of flows in the standby path **970** and to encapsulate a received frame with a header including the common identifier.

The figure U-A shows a configuration of a frame which is received from the AE **112** by the BHE **172** when an uplink signal is relayed. A frame header **30010** includes an identifier field H**101**, and the identifier inserts an identifier (for example, LSP-I in FIG. **22** or FIG. **23**) for communication in the standby system path **922** in the AE **112**. According to the first relay method, the BHE **172** changes LSP-I into a header H**102** (LSP-Z) for transfer to the standby path **970** when the frame is transferred, and transfers the frame to the BHE **171**. When the frame including the identifier H**102** (LSP-I) is received, the BHE **171** converts the identifier H**102** into an identifier H**105** (VLAN-Y) which should be inserted when communication from the AE **112** is transferred in a normal operation, and sends the frame to the core network. In the series of processes, the BHE **172** refers to the transfer table **5110** and the inter-BHE path table **5510** (FIG. **22**), determines whether or not a frame is to be transferred to the standby path **970** from the reception interface and the received frame header information, and inserts an appropriate frame identifier into the frame which is transferred. On the other hand, the BHE **171** grasps a correspondence relationship between the identifier H**102** (LSP-I) of the frame header and a frame identifier in a normal operation path, and replaces the identifier with the identifier (VLAN-Y) set in advance in a normal operation when transferring the frame to the core network (more generally, processes of related header information as well as the identifier are performed). In the configuration of FIG. **22**, the inter-BHE path table **5510** is held, and thereby it is possible to understand a header process when transfer is performed in a normal operation. The transfer table **5110** shows a correspondence relationship between identification information of a received frame and identifier information appended when a frame is sent, and the information forms an entry based on the inter-BHE path table **5510** as described above.

In the second relay method, a frame configuration shown in the figure U-B**2** is used. In this case, a received frame is encapsulated in an original form and is transferred to the BHE **171** via the standby path **970**. The BHE **171** can recognize that the frame passes through the standby path **970** from a reception path of the frame. Since the frame configuration is maintained and the frame is transmitted to the BHE **171**, the frame identifier H**104** for a standby system path appended by the AE **112** can be referred to. Thereby, it is possible to perform a frame process in a general linear redundant system between the AE **112** and the BHE **171** regardless of the presence of the BHE **172** which works as relay equipment. A process required by the BHE **171** is only a process selection function for treating a frame from which a primary header is deleted as a normally received frame in relation to a signal from the standby path, in addition to communication (header information) settings in an active system path with the AE **112** and communication settings in a standby system path.

This is also substantially the same for a downlink signal. Frame configurations D-B**1** and D-B**2** respectively show frame configuration examples corresponding to the first relay method and the second relay method. In the first method, a process when a frame is transferred from the BHE **172** to the AE **112** is the same as in the uplink signal, and an identifier H**205** directed to the AE **112** corresponding to the identifier H**202** is inserted into the frame which is transferred. In the second method, the frame identifier H**201** does not vary when the frame is received from the core network before and after the frame passes through the standby path **970**. Therefore, the BHE **172** is required to insert an identifier used in a linear redundant system in which the BHE **171** and the AE **112** form both ends. The identifier information can be realized by mutual notifications of path information between the BHEs **172** and **171**. As a result, if the table shown in FIG. **21** can be built, the first and second methods can be applied.

FIG. **29** is a signal configuration diagram illustrating a configuration example of the CCM frame. Path monitoring using the frame starts along with operation start of an individual path or flow.

A frame configuration in this figure includes a destination address (DA) **10010**, a transmission source address (SA) **10020**, an MPLS header **10030** as L2 information, and a payload **10040**. Equipment which receives this frame can determine a frame type, for example, by referring to a predetermined label value **10031** indicating an OAM frame.

Information of which a notification is to be sent using the CCM frame is stored in the payload **10040** part. Specific information examples include an MEG level (identification information indicating a logical connection relationship set in a monitoring target path, called a Maintenance Entity Group Level) **10041**, OAM version information **10042**, a code number OpCode (**10033**) indicating the CCM frame, Flags (**10034**) indicating a transmission cycle of the CCM frame and other additional function information, a sequence number field **10045**, an MEP ID (**10046**) indicating equipment ID which sends the CCM frame, logical identification information MEG ID (**10047**) of a monitoring target path, and a field **10048** for other control informations. Details of the defined

fields of the CCM frame are described in the ITU-T or IEEE standard regulations, and thus description thereof will be omitted here.

FIG. **30** is a signal configuration diagram illustrating a configuration example of the switching request frame **20001**, transfer request frame **20002**, and process completion notification (ACK) frames **30000** and **40000**.

The figure (A) shows a configuration example of the switching request frame **20001** which is transmitted from the AE **112** to the BHE **172** and the transfer request frame **20002** which is transmitted from the BHE **172** to the BHE **171**. This configuration example is based on a Vendor Specific Message (VSM) frame format defined in ITU-T Y.**1731**.

L2 information (**10010**, **10020**, and **10030**) of the frame configuration of this figure is the same as in FIG. **29**, and thus description thereof will be omitted. In addition, in relation to MEL (**10041**) which is basic payload information of the OAM frame, OAM version information **10042**, and a code number OpCode (**10053**) indicating a VSM frame, a meaning indicated by each field is the same as in the frame configuration example of FIG. **28**. Further, Operatally Unique Parameters (OUI) **10050** and SubOpCode (**10051**) are described in G.**8031**, and thus description thereof will be omitted here.

In the present embodiment, information of which a notification is to be sent from the AE **112** to the BHE **172** and from the BHE **172** to the BHE **171** is stored in the payload **10040** part. Specifically, a part of the control information field **10060** is used. This includes an instruction content regulation field **10061** for requesting a switching process and a transfer process, and a reserve field **10062** for inserting other flags or the like. In addition, the reserve field **10062** is an option.

The figure (B) shows a configuration example of the ACK frame which is transmitted from the BHE **171** to the BHE **171**. An ACK frame which is transmitted from the BHE **172** to the AE **112** also has the same configuration. The switching completion notification (ACK) message **30000** (or **40000**) includes a switching completion notification field (**10063**) to which the instruction content regulation field **10061** used in the figure (A) is rewritten.

In the above-described embodiment, the path switching method using detection of communication failures by the AE **112** as a trigger has been described. Hereinafter, a description will be made of a path switch method when the BHE **171** or the BHE **172** detects path failures.

B. Second Embodiment

FIG. **31** is a network configuration diagram illustrating a path switching method in a case where failures in uplink communication are recognized from arrival circumstances of a CCM signal when the BHE **171** monitors the CCM frame from the AE **112**. When failures are detected, the BHE **171** first transmits a transfer request frame **20003** for requesting relay (relay of the signal in the BHE **172**) of an uplink signal which is directed to the BHE **171** from the AE **112**, to the BHE **172**. The BHE **172** which has received the transfer request frame **20003** updates the transfer table **5110**, the inter-BHE path table **5510**, the delay table **5210**, and the management table **5310** therein, and sends a switching request frame **20004** for switching an uplink signal sending path from the active system path **921** to the standby system path **922**, to the AE **112**.

Frame configuration examples of the transfer request frame **20003** and the switching request frame **20004** are the same as the signal configuration shown in FIGS. **30**(B) and **30**(A) respectively. Only the frame type identifier **10061** or **10063** of the payload **10060** may be changed. In addition, the other-information field **10062** includes an identifier of a path which is set as a switching/transfer target by the frame, and an identifier of a path after being switched, and thereby the BHE **172** or the AE **112** which receives the signal can clearly recognize changed contents.

FIG. **32** is a sequence diagram illustrating a flow of a path switching process in the second embodiment. This figure shows an example of using an ACK signal in order to confirm notification completion of the control signal and path switching/transfer process completion in the opposite equipment BHE **172** or the AE **112**, in transmission of the transfer request frame **20003** from the BHE **171** to the BHE **172** and transmission of the switching request frame from the BHE **172** to the BHE **171**. As another method, a path switching means which uses a timer is possible as shown in FIGS. **5** to **9**. In any means, transmission and reception of a control signal between equipments or a signal processing method inside equipment is approximately the same as the sequence shown in FIGS. **5** to **9**, thus process procedures will be described by exemplifying a case using an ACK frame in the second embodiment, and an example employing a time will be omitted.

In order to monitor communication circumstances from the AE **112** to the BHE **171**, the AE **112** periodically sends a CCM frame to the communication path **921**. An arrival time point and an arrival time interval of the CCM frame are confirmed and are recorded. In this figure, a state is shown in which the CCM frame arrives last at a time point S**700** and the BHE **171** fails to observe the arrival of a series of CCM frames.

In a case where the BHE **171** cannot confirm reception of a subsequent CCM frame within a specific time set in advance (S**701**), it is determined that failures occur in the path (S**702**). Then, in the BHE **171**, the failure monitoring unit **5400** instructs the frame generation unit **6230** or **6470** to generate a transfer request frame, and notifies the reading control unit **6280** or **6460** of an instruction for sending of the transfer request frame so as to start sending the transfer request frame **20003-1** and transfer request frame **20003-2**.

When the transfer request frame **20003** is received, the BHE **172** transitions to a path switching state (that is, starts a path switching process) (S**704**). Here, the BHE **172** changes the transfer table **5110**, the management table **5310**, the inter-BHE path table **5510**, and the delay table **5210** regarding a path or a flow of which a notification is sent from the BHE **171**. A configuration method and an update method of each database are the same as the methods described in the first embodiment, and thus description thereof will be omitted. When the process in the BHE **172** is completed, the path switching request frames **20004-1** and **20004-2** are sent to the AE **112**. The AE **112** which has received the instruction changes an uplink signal sending path from the active system path **921** to the standby system path **922**. When update of the transfer table **1110**, the management table **1310**, and the delay table **1210** of the AE **112** is completed in relation to this change, the AE **112** sends change completion notification frames (ACK frames) **50000** (**50000-1**, **50000-2**, . . .) to the BHE **172**. The BHE **172** which has received the ACK frame **50000** confirms completion of settings therein, and sends switching completion notifications (ACK frames) **60000** (**60000-1**, **60000-2**, for informing of setting completion of a communication path using the standby system path **922** and the standby path **970**, to the BHE **171**. The BHE **171** resumes communication with the AE **112** when the ACK frame **60000** is received. Data communication from the AE **112** to the BHE **172** and from the BHE **172** to the BHE **171** may be resumed after the AE **112** and the BHE **172** start sending an ACK signal. When the data communication is resumed, the CCM frame may be transmitted from the AE **112** to the BHE **171** via

the BHE **172**, and thereby a communication path state may be checked. At this time, for example, if the AE **112** can normally receive the CCM frame from a reverse communication path which is directed to the AE **112** from the BHE **171**, it can be determined that a state in which data communication can be resumed happens.

C. Third Embodiment

FIG. **32** is a network configuration diagram illustrating a state in which three or more relay network edge equipment BHEs on the core networks **210** and **220** side are connected to a single access side edge equipment AE in the relay network **10** of FIG. **1**. Hereinafter, a description will be made of another path switching method in the relay network **10**.

In the paths **911**, **912**, **921**, **922**, **923**, **931**, **932**, and **933** formed in the relay network **10**, in order to check normality of a packet communication path, the CCM frame is periodically transmitted in the same manner as in the configuration of FIG. **1**. In the present embodiment, circumstances are shown in which a communication failure **300-1** occurs in the active system path **921** located at the shortest communication distance, and the first standby system **922** is used as a communication path.

In this figure, attention is paid to a signal process in a redundant system path formed by the AE **112** and the BHEs **171**, **172** and **173**, and this will be described as a representative example. Also here, the AE **112** will be described as a representative example; however, frame transmission and reception and the path switching method of the AE **111** and the AE **113**, and the BHEs **171**, **172** and **173** are the same as in FIG. **1**.

A frame transfer process is performed by referring to a table held in the transfer table (FIG. **10**: **1110**) provided in the AE, the BHE, and relay communication equipment using the paths **921**, **922** and **923**. A method of forming and referring to the transfer table (FIG. **10**: **1110**) is approximately the same as the description of FIG. **2**. Further, as described with reference to FIG. **2**, for example, there is a possibility that a communication signal (including the CCM frame) from the AE **112** to the BHE **171** and a communication signal (including the CCM frame) from the BHE **171** to the AE **112** may pass through the same physical line, and there is a possibility that the signals may pass through paths (physically) different from each other and be transmitted and received in a case where a plurality of physical lines are installed. In the present embodiment, a description will be made of a method of handling (path switching) failures regarding communication from the AE **112** to the CRE **211** (the BHE **171**) as a representative example.

In a case where connectivity is not confirmed in this configuration, path switching is performed between the AE **112** and the BHE **171** so as to secure continuity of communication. In the circumstances of this figure, the path failure **300-1** has already disrupted communication from the AE **111** to the BHE **171**. In addition, it is considered that a second failure **300-2** occurs, and it is difficult to continuously perform communication using the standby system path **922**.

The path failure **300-2** can be detected when periodical reception of a CCM frame by the BHE **172**, transmitted from the AE **112** to the BHE **172**, stops. The BHE **172** determines that it is difficult to continuously perform communication in the path **922** through this detection.

When the path failure **300-2** is detected, the BHE **172** requests the BHE **173** to relay communication with the BHE **171** by using a replacement system path (accurately, a part thereof) **923** which is set in advance from the BHE **171** via the BHE **173**. This request uses, for example, the switching request frame **20001** (FIG. **30**). When the request is received, the BHE **173** requests the AE **112** to switch a frame transfer path directed to the transmission destination BHE (here, the BHE **171**). In other words, the AE **112** is requested to change signal distribution settings so as to send a frame directed to the BHE **171** sent by the AE **112** to the BHE **173** using the standby path **923**.

In addition, in FIG. **33**, the paths **970-1** and **970-2** are communication paths (a portion thereof) used after a communication path is changed from the path **921** to the path **922** after the failure **300-1** occurs. As in the present embodiment, when the second failure **300-2** occurs, communication between the AE **112** and the BHE **171** is continuously performed using still another path **970-3**. The BHEs **171**, **172** and **173** are connected to each other using a topology in which a pair of BHEs can communicate with each other. As an example of the topology, there is a mesh type or a ring type connection form between the BHEs which can be used. In this figure, a mesh type connection is exemplified.

FIG. **34** is a communication path configuration diagram illustrating a standby system path configuration method in a case where connectivity is not confirmed due to the second failure **300-2** in the communication circumstances checking process described in FIG. **33**. As described in FIG. **33**, this figure shows a path configuration example in a case where an abnormal state (or an abnormal operation) is detected when the CCM frame **10000** is delivered.

This figure shows a replacement system (standby system) in which a signal output from the AE **112** passes through the BHE **173** and arrives at the BHE **171** as a communication path after the path **922** is switched to the path **923**.

In the same manner as the path switching methods (FIGS. **1** to **32**) for the first failure, a feature different from the existing switching method (for example, ITU-T Recommendation G.**8031**) lies in that the BHE **173** is a relay point of a switching request signal and communication after path changing. In other words, a tree type communication network in which the BHE **173** is a top forms a sub-tree when viewed from the BHE **171**. In this figure, the BHEs **171**, **172** and **173** are mesh-connected to each other, and this forms a pyramidal (conical) topology in which three communication paths are connected to a flat mesh network **3300** formed by three equivalent communication equipments (BHEs) when viewed from the AE **112**. A communication signal from the AE **112** to the core network **210** is input to the mesh network **3300** which corresponds to the bottom side of the pyramid and arrives at the core network **210** via the BHE **171**.

A feature of an operation realized by the pyramidal connection is derived from a configuration in which (1) the BHEs **171**, **172** and **173** are communication relay (collection) equipment having an equivalent function, and (2) all the AEs **111** to **113** are connected to the BHEs **171**, **172** and **173** in advance via paths **921**, **922** and **923** which are independent from one another. Using the feature of (1), the connection relationship among the BHEs **171**, **172** and **173** is changed at random, and thereby the AE **112** can freely change a single hierarchical tree to which the equipment belongs in a certain time point. Further, the communication path between the BHEs is used for data communication as a bypass path, and thereby a form of the communication network is changed to a multi-hierarchical tree of two or more hierarchies (realized by a pyramidal structure in which two or more BHEs are connected to one another) so as to continuously perform communication even in a failure. In addition, if using the feature of (2), when a path change which depends on a communication network building plan is needed, it is possible to secure a communication path having an equivalent performance and to change easily without labors such as installation of lines or movement of equip-

ment. Further, there is also a method in which an existing protection switching technique determines an operation system and a standby system (switched destination) in advance for each communication unit (for example, "connection" or "path") as indicated by 1+1 or 1:1 (generally, N+M type or N:M type (a method of preparing for M standby paths in order to protect N items of communication)). In this case, if each item of communication is to be more reliably protected, communication network resources which are preliminarily necessary increase to that extent. In contrast, in the present embodiment, communication is collected in the BHEs **171** and **172**, the standby path **970** connecting between the BHEs is shared as a standby path, and thereby it is not necessary to secure a large number of network resources. In addition, since there is a low probability that a plurality of path failures may occur, a part of the communication path **3300** is connected to all the paths **921**, **922** and **923** so as to form a communication path between the AE **112** and the BHE **171**, and thereby it is possible to effectively use the resources. In the existing protection switching technique, only a single communication unit is protected for a single standby line (the number of settings), but the standby path **3300** can be assigned to all items of communication in the configuration of FIG. **34**. The cost-effectiveness thereof is high. Generally, when the number of accommodated items of communication (the number of collections) is taken into consideration, the BHEs **171**, **172** and **173** are higher in a process performance of the communication equipment than the AE **112**. In most cases, the BHE employs a configuration of equipment itself with the higher reliability than the AE. Further, a large capacity line is easily to be used for the standby path **3300** between the BHEs, and, since traffics do not flow into the standby path **3300** in a normal operation, it is easy to cope with the emergency.

In this figure, the arrows **3310** and **3320** indicating the signal transmission path and direction, and the arrows **3352**, **3353** and **3330** indicating signals from the AE **112** to the BHE **171** indicate a flow of the switching control signal described in FIG. **34** and signals from the AE **112** to the BHE **171** after the path is switched. Procedures of the path switching process will be described in detail with reference to FIG. **35**.

In this way, the relay equipment monitors communication circumstances, and a location closer to a failure point detects a failure when the failure occurs, thereby shortening time until handling of the failure starts as compared with the typical protection switching. This is realized by equipment relaying communication having a function equivalent to that of equipment which is an end point of the communication. Here, the equivalent function also includes requirements in terms of network design such as a function of playing a role as edge equipment of the relay network **10** and including table information in addition to a function of processing a user (data) signal and a control signal. For this reason, there is provided a function of capable of transmitting and receiving table setting information between the BHEs, and control information is exchanged via the core network side edge mesh network **3300**.

FIG. **35** is a sequence diagram illustrating a flow of a path switching process in the path configuration example of FIGS. **33** and **34**. This figure shows an example using an ACK signal in order to confirm notification completion of a control signal and path switching/transfer process completion in the opposite equipment AE **112**, in transmission of a switching notification transmission request frame **3310** from the BHE **172** to the BHE **173** and transmission of a switching request frame (not shown) from the BHE **172** to the BHE **171**. As another switching completion determining means, a method which uses a timer is possible as shown in FIGS. **5** to **9**. In any means, transmission and reception of a control signal between equipments or a signal processing method inside equipment is approximately the same as the sequence shown in FIGS. **5** to **9**, thus process procedures will be described by exemplifying a case using an ACK frame in the embodiment, and an example employing a timer will be omitted.

In order to monitor communication circumstances from the AE **112** to the BHE **171**, the AE **112** periodically sends a CCM frame to the communication path **922**. An arrival time point and an arrival time interval of the CCM frame are confirmed and are recoded. In this figure, a state is shown in which the CCM frame arrives last at a time point S**999** and the BHE **172** fails to observe the arrival of a series of CCM frames.

In a case where the BHE **172** cannot confirm reception of a subsequent CCM frame within a specific time set in advance (S**1001**), it is determined that failures occur in the path (S**1002**). Then, in the BHE **172**, the failure monitoring unit **5400** instructs the frame generation unit **6230** or **6470** to generate switching notification transmission request frame **3310**, and notifies the reading control unit **6280** or **6460** of an instruction for sending of the request frame **3310** so as to start sending the switching notification transmission request frame **3310** (in this figure, **34001-1** and **34001-2**) (S**1003** and S**1004**).

When the switching notification transmission request frames **34001-1** and **34001-2** which are equal to or more than a predetermined number are received, the BHE **173** transitions to a path switching state (that is, starts a path switching process) (S**1005**). Here, the BHE **173** changes the transfer table **5110**, the management table **5310**, the inter-BHE path table **5510**, and the delay table **5210** regarding a path or a flow of which a notification is sent from the BHE **172**. A configuration method and an update method of each database are the same as the methods described in the first and second embodiments, and thus description thereof will be omitted. When the process in the BHE **173** is completed (S**1006**), the path switching request frames **34002-1** and **34002-2** are sent to the AE **112**. The AE **112** which has received the instruction changes an uplink signal sending path from the active system path **922** to still another standby system path **923**. When update of the transfer table **1110**, the management table **1310**, and the delay table **1210** of the AE **112** is completed in relation to this change, the AE **112** sends change completion notification frames (ACK frames; not shown) to the BHE **172**. When the ACK frames are received, the BHE **173** regards settings therein and path switching as being completed (S**1008**). Successively, a switching completion notification (ACK frame; an ACK frame directed to the BHE **171** is not shown) **34003-1** is sent so as to inform the BHE **171** and the BHE **172** of setting completion of a communication path using the standby system path **923** and the standby path **970-3**. When the ACK frames **34003-1** which are equal to or more than a predefined number are received, the BHE **172** determines that the switching is completed, and resumes communication with the AE **112**. In addition, as another procedure, data communication from the AE **112** to the BHE **173** and from the BHE **173** to the BHE **171** may be resumed after the AE **112** and the BHE **172** start sending an ACK signal. When the data communication is resumed, the CCM frame may be transmitted from the AE **112** to the BHE **171** via the BHE **173**, and thereby a communication path state may be checked.

FIG. **36** is a flowchart illustrating process procedures when a data frame or a control (for example, CCM) frame is received by the header analysis unit **6260** of the BHE **172**.

The processes in steps F**1001** and F**1002** are approximately the same as the procedures of FIG. **17** which show the process method of the CCM frame. In the present embodiment, the BHE **172** is operated as relay equipment of a communication path from the AE **112** to the BHE **171**. Hereinafter, frame process procedures in the path control unit are extracted and are shown.

When a frame is received by the interface of the BHE **172** (F**1001**), the BHE extracts an identifier of a path through which the frame should pass based on header information of the frame (F**1002** and F**1003**). In a case where the frame is a CCM frame, and the path through which the frame passes is a path in which the self equipment is an end point (the core network is connected to the access network via the self equipment) (F**1004** to F**1007**), the CCM frame is terminated. An analysis process of reception circumstances of the CCM frame after the termination is the same as described above, and thus repeated description thereof will be omitted (F**1008**). In addition, if the self equipment is not an end point, the CCM frame is transferred to another BHE which is an end point (F**1009**). At this time, in relation to a path in which the self equipment should be operated as relay equipment, an arrival interval of the CCM frame is confirmed, and a preliminary operation for handling failure detection and path switching is performed (F**1006**, F**1007**, and F**1009**).

If the CCM frame is confirmed in F**1005** and F**1006**, it is confirmed in F**1003** that the request frame is received from a correct path, and, then, it is detected that failures occur in the path, the BHE **171** is requested to perform path switching so as to use the standby path, thereby securing a communication path using the standby path **970-3** (F**1004**). Specifically, the BHE **171** is instructed to change the transfer table so as to receive an upward communication signal from the AE **112**. This switching request frame (not shown) is generated by the frame generation unit **6230**.

Further, in order to continuously perform uplink communication of the flow via the BHE **173**, the path control unit **5100** sends an instruction frame so as to change the path information of the transfer table **5110** of the AE **112**, thereby changing the communication from the AE **112** to the BHE **173**. This process is performed using a system switching instruction frame **34002**.

FIG. **37** is a flowchart illustrating procedures of a path switching process in the path control unit when the BHE **172** detects the failure **300-2**.

This process starts at a time point when a failure is detected. A location of the detected failure on a target path of the self equipment is confirmed in step F**1101**. If the equipment is an end point of the path, the path switching process described in FIGS. **1** to **32** is performed (F**1102**). Here, for example, a path switching request is transmitted to the AE **112** and the BHE **171**, and thereby communication from the AE **112** to the self equipment is secured. The opposite equipment described in F**1102** indicates the AE **112** in this case.

There is a high probability that the failure **300-1** may occur before the failure **300-2** in the path in which the self equipment is set as relay equipment. Therefore, first, it is checked whether or not the active path (the path **921** in the examples of FIGS. **32** and **33**) is recovered (is in an available state) in relation to the path (F**1103**). If the path **921** is available, a path switch-back process F**1108** is performed. Specifically, the AE **112** is instructed to change a sending path (from the path **922** to the path **921**) of an uplink signal, and, further, the BHE **171** is instructed to change a reception path so as to receive a frame from the AE **112**.

In a case where the active system path **921** is not recovered at the time point when the failure **300-2** occurs, other paths are selected (F**1104**). In this case, since a third path passing through the BHE **173** is available, the BHE **173** which is relay equipment of an available path and the AE **112** which is a transmission source of an uplink signal are respectively instructed to change a reception path and a transmission path in steps F**1106** and F**1107**. In addition, if other standby systems cannot be selected in step F**1104**, a communication stop warning is transmitted to the path control unit (F**1105**).

The invention claimed is:

1. A communication network system comprising:

a plurality of edge equipments (AEs) on an access line side that accommodate an access line; and

a plurality of backhaul edge equipments (BHEs) connected to a network side,

wherein each of the BHEs

is located at a top of a tree structure formed in a relay network including the plurality of AEs, and includes communication paths with the plurality of AEs;

includes an intercommunication path through which a data signal does not flow in a normal operation and the data signal is mutually transmitted and received as a traffic accommodation path in an emergency between each of the plurality of BHEs, each of which is at the top of the tree structure; and

includes a BHE transfer table which stores in advance a correlation between an input communication path and an output communication path, and an inter-BHE path table which stores in advance a correlation between an input communication path and an output communication path in the intercommunication path,

wherein each of the plurality of AEs

has communication paths for the plurality of BHEs, and is connected to the plurality of BHEs in advance via paths independent from one another;

sets an active system path for one of the plurality of BHEs which are tops of a plurality of tree structures to which the self AE belongs, and sets a standby system path for one or a plurality of BHEs among the other BHEs;

wherein

the AE, in a normal operation state, receives data communication from a first BHE, and periodically receives a connection checking frame for checking normality of a communication path in order to monitor communication circumstances of a first communication path between the AE and the first BHE;

the AE determines that a failure occurs in the first communication path when a subsequent connection checking frame is not received until a specific time has elapsed; and

the AE sends a path switching request frame to a second BHE using a second communication path with the second BHE in which abnormality is not recognized on the communication path,

wherein,

when the second BHE receives the path switching request frame transmitted by the AE,

the second BHE recognizes that some sort of problem which disrupts continuous communication between the AE and the first BHE occurs;

the second BHE makes the second communication path connected between the AE and the second BHE valid as a main signal path in a second BHE transfer table in the second BHE, sets a communication path directed to the AE using the intercommunication path connecting the first BHE and the second BHE for a downlink signal to

the AE, and changes settings so as to set a transmission path by the intercommunication path for an uplink signal from the AE; and

the second BHE further transmits a transfer request frame for accommodating communication which is directed to the AE from the first BHE in the intercommunication path, to the first BHE,

wherein,

when the first BHE receives the transfer request frame from the second BHE, the first BHE changes settings in the first BHE transfer table in the first BHE so as to switch a path, which receives an uplink signal from the AE, from the first communication path to the intercommunication path; and

the first BHE further changes settings in the first BHE transfer table so as to transfer a downlink signal directed to the AE received from the network to the intercommunication path, in relation to the downlink signal to the AE which has been transferred using the first communication path connecting the first BHE to the AE, and

wherein a sub-tree having a sub-tree structure in which the second BHE of a standby system by passing a failure point is placed as a top is built under the first BHE of an active system, and communication between the AE and the first BHE of the active system is relayed by a standby system path via the second BHE of the standby system.

2. The communication network system according to claim **1**,

wherein the AE completes transmission of the switching request frame after stopping or waiting for a user data frame process for a specific time, and resumes sending of user data frames which are accumulated in the AE during a switching process.

3. The communication network system according to claim **1**,

wherein, when a specific time has elapsed from a start of sending of the transfer request frame or an ACK signal for the transfer request frame is received from the first BHE, the second BHE confirms that information update of a second BHE transfer table and/or a second inter-BHE path table in the second BHE is completed, and then sends the ACK signal for notifying the AE of transfer preparation completion, and

wherein, when the ACK signal is received, the AE changes a transmission destination from the first communication path to the second communication path from that point, and starts communication to the network via the second BHE.

4. The communication network system according to claim **1**,

wherein, when the transfer request frame is received from the second BHE, the first BHE sends an ACK signal for notifying the second BHE of transfer preparation completion, after path setting in the first BHE transfer table and/or the first inter-BHE path table in the first BHE is completed,

wherein, when the ACK signal is confirmed, the second BHE transmits an ACK frame for notifying of preparation completion to the AE via the second communication path, and

wherein, when the ACK frame is confirmed, the AE changes a transmission destination from the first communication path to the second communication path from that point, and starts communication to the network via the second BHE.

5. The communication network system according to claim **1**,

wherein the BHE transfer table and/or the inter-BHE path table correlate an input communication path with an output communication path, and further store identification information of active and standby or identification information of a failure in advance, and

wherein, when arrival of a path switching request frame is recognized, the second BHE sets a flag of the identification information of active and standby or the identification information of a failure in standby system path information which is set in the second BHE transfer table and/or the second inter-BHE path table in advance, and makes an entry of the intercommunication path valid to perform path switching on a targeted flow.

6. A communication network system comprising:

a plurality of edge equipments (AEs) on an access line side that accommodate an access line; and

a plurality of backhaul edge equipments (BHEs) connected to a network side,

wherein each of the BHEs

is located at a top of a tree structure formed in a relay network including the plurality of AEs, and includes communication paths with the plurality of AEs;

includes an intercommunication path through which a data signal does not flow in a normal operation and the data signal is mutually transmitted and received as a traffic accommodation path in an emergency between each of the plurality of BHEs, each of which is at the top of the tree structure; and

includes a BHE transfer table which stores in advance a correlation between an input communication path and an output communication path, and an inter-BHE path table which stores in advance a correlation between an input communication path and an output communication path in the intercommunication path,

wherein each of the plurality of AEs

has communication paths for the plurality of BHEs, and is connected to the plurality of BHEs in advance via paths independent from one another;

includes an AE transfer table which stores in advance a correlation between an input communication path and an output communication path, sets an active system path for one of the plurality of BHEs which are tops of a plurality of tree structures to which the self AE belongs, and sets a standby system path for one or a plurality of BHEs among the other BHEs;

wherein

a first BHE, in a normal operation state, receives data communication from the AE, and periodically receives a connection checking frame for checking normality of a communication path in order to monitor communication circumstances of a first communication path between the AE and the first BHE;

the first BHE determines that a failure occurs in the first communication path when a subsequent connection checking frame is not received until a specific time has elapsed; and

the first BHE sends a transfer request frame to a second BHE using an intercommunication path connected to the second BHE,

wherein,

when the second BHE receives the transfer request frame transmitted by the first BHE,

the second BHE recognizes that some sort of problem which disrupts continuous communication between the AE and the first BHE occurs;

the second BHE makes the second communication path connected between the AE and the second BHE valid as a main signal path in a second BHE transfer table in the second BHE, sets a communication path directed to the AE using the intercommunication path connecting the first BHE and the second BHE for a downlink signal to the AE, and changes settings so as to set a transmission path by the intercommunication path for an uplink signal from the AE; and

the second BHE further sends a switching instruction frame to the AE so as to switch an uplink signal sending path from the first communication path to a second communication path with the second BHE, in which abnormality is not recognized on the communication path, and

wherein the AE changes settings in the AE transfer table so as to switch an uplink signal sending path from the first communication path to the second communication path with the second BHE, in which abnormality is not recognized on the communication path, when the switching instruction frame is received, and

wherein,

on the other hand, the first BHE changes settings in the first BHE transfer table in the first BHE so as to switch a path, which receives an uplink signal from the AE, from the first communication path to the intercommunication path; and

the first BHE further changes settings in the first BHE transfer table so as to transfer a downlink signal directed to the AE received from the network to the intercommunication path, in relation to the downlink signal to the AE which has been transferred using the first communication path connecting the first BHE to the AE, and

wherein a sub-tree having a sub-tree structure in which the second BHE of a standby system by passing a failure point is placed as a top is built under the first BHE of an active system, and communication between the AE and the first BHE of the active system is relayed by a standby system path via the second BHE of the standby system.

7. The communication network system according to claim **6**,

wherein, in a case where the AE has already been connected to the first BHE via the second communication path and the second BHE due to a failure regarding the first communication path connecting the AE to the first BHE,

when the second BHE detects a failure regarding the second communication path according to stop of periodical reception of a connection checking frame which is transmitted from the AE to the second BHE,

the second BHE sends a switching request frame to a third BHE using the intercommunication path,

wherein,

when the third BHE receives the switching request frame transmitted by the second BHE,

the third BHE recognizes that some sort of problem which disrupts continuous communication between the AE and the second BHE occurs;

the third BHE makes the third communication path connected between the AE and the third BHE valid as the main signal path in a third BHE transfer table in the third BHE, sets a communication path directed to the AE using the intercommunication path connecting the first BHE and the third BHE for a downlink signal to the AE, and changes settings so as to set a transmission path by the intercommunication path for an uplink signal from the AE; and

the third BHE further sends a switching instruction frame to the AE so as to switch an uplink signal sending path from the first communication path to a third communication path with the third BHE, in which abnormality is not recognized on the communication path, and

wherein the AE changes settings in the AE transfer table so as to switch an uplink signal sending path from the first communication path to the second communication path with the second BHE, in which abnormality is not recognized on the communication path, when the switching instruction frame is received, and

wherein,

on the other hand, the first BHE changes settings in the first BHE transfer table in the first BHE so as to switch a path, which receives an uplink signal from the AE to the intercommunication path connected to the third BHE; and

the first BHE further changes settings in the first BHE transfer table so as to transfer a downlink signal directed to the AE received from the network to the intercommunication path connected to the third BHE, in relation to the downlink signal to the AE, and

wherein a sub-tree having a sub-tree structure in which the third BHE of a standby system by passing a failure point is placed as a top is built under the first BHE of an active system, and communication between the AE and the first BHE of the active system is relayed by a standby system path via the third BHE of the standby system.

8. A communication network configuration method using a communication network system comprising:

a plurality of edge equipments (AEs) on an access line side that accommodate an access line; and

a plurality of backhaul edge equipments (BHEs) connected to a network side,

wherein each of the BHEs

being at a top of a tree structure formed in a relay network including the plurality of AEs, and including communication paths with the plurality of AEs;

including an intercommunication path through which a data signal does not flow in a normal operation and the data signal is mutually transmitted and received as a traffic accommodation path in an emergency between each of the plurality of BHEs, each of which is at the top of the tree structure; and

including a BHE transfer table which stores in advance a correlation between an input communication path and an output communication path, and an inter-BHE path table storing in advance a correlation between an input communication path and an output communication path in the intercommunication path,

wherein each of the plurality of AEs

providing communication paths for the plurality of BHEs, and is connected to the plurality of BHEs in advance via paths independent from one another;

setting an active system path for one of the plurality of BHEs which are tops of a plurality of tree structures to which the self AE belongs, and setting a standby system path for one or a plurality of BHEs among the other BHEs;

wherein

the AE, in a normal operation state, receiving data communication from a first BHE, and periodically receives a connection checking frame for checking normality of a communication path in order to monitor communication circumstances of a first communication path between the AE and the first BHE;

the AE determining that a failure occurs in the first communication path when a subsequent connection checking frame is not received until a specific time has elapsed; and

the AE sending a path switching request frame to a second BHE using a second communication path with the second BHE in which abnormality is not recognized on the communication path,

wherein,

when the second BHE receives the path switching request frame transmitted by the AE,

the second BHE recognizing that some sort of problem which disrupts continuous communication between the AE and the first BHE occurs;

the second BHE causing the second communication path connected between the AE and the second BHE valid as a main signal path in a second BHE transfer table in the second BHE, setting a communication path directed to the AE using the intercommunication path connecting the first BHE and the second BHE for a downlink signal to the AE, and changing settings so as to set a transmission path by the intercommunication path for an uplink signal from the AE; and

the second BHE further transmitting a transfer request frame for accommodating communication which is directed to the AE from the first BHE in the intercommunication path, to the first BHE,

wherein,

when the first BHE receives the transfer request frame from the second BHE, the first BHE changing settings in the first BHE transfer table in the first BHE so as to switch a path, which receives an uplink signal from the AE, from the first communication path to the intercommunication path; and

the first BHE further changing settings in the first BHE transfer table so as to transfer a downlink signal directed to the AE received from the network to the intercommunication path, in relation to the downlink signal to the AE which has been transferred using the first communication path connecting the first BHE to the AE, and

wherein a sub-tree having a sub-tree structure in which the second BHE of a standby system by passing a failure point being placed as a top is built under the first BHE of an active system, and communicating between the AE and the first BHE of the active system is relayed by a standby system path via the second BHE of the standby system.

9. A communication network configuration method using a communication network system comprising:

a plurality of edge equipments (AEs) on an access line side that accommodate an access line; and

a plurality of backhaul edge equipments (BHEs) connected to a network side,

wherein each of the BHEs

being at a top of a tree structure formed in a relay network including the plurality of AEs, and including communication paths with the plurality of AEs;

including an intercommunication path through which a data signal does not flow in a normal operation and the data signal is mutually transmitted and received as a traffic accommodation path in an emergency between each of the plurality of BHEs, each of which is at the top of the tree structure; and

including a BHE transfer table which stores in advance a correlation between an input communication path and an output communication path, and an inter-BHE path table storing in advance a correlation between an input communication path and an output communication path in the intercommunication path,

wherein each of the plurality of AEs

providing communication paths for the plurality of BHEs, and is connected to the plurality of BHEs in advance via paths independent from one another;

including an AE transfer table storing in advance a correlation between an input communication path and an output communication path, setting an active system path for one of the plurality of BHEs which are tops of a plurality of tree structures to which the self AE belongs, and setting a standby system path for one or a plurality of BHEs among the other BHEs;

wherein

a first BHE, in a normal operation state, receiving data communication from the AE, and periodically receives a connection checking frame for checking normality of a communication path in order to monitor communication circumstances of a first communication path between the AE and the first BHE;

the first BHE determining that a failure occurs in the first communication path when a subsequent connection checking frame is not received until a specific time has elapsed; and

the first BHE sending a transfer request frame to a second BHE using an intercommunication path connected to the second BHE,

wherein,

when the second BHE receiving the transfer request frame transmitted by the first BHE,

the second BHE recognizing that some sort of problem which disrupts continuous communication between the AE and the first BHE occurs;

the second BHE causing the second communication path connected between the AE and the second BHE valid as a main signal path in a second BHE transfer table in the second BHE, setting a communication path directed to the AE using the intercommunication path connecting the first BHE and the second BHE for a downlink signal to the AE, and changing settings so as to set a transmission path by the intercommunication path for an uplink signal from the AE; and

the second BHE further sending a switching instruction frame to the AE so as to switch an uplink signal sending path from the first communication path to a second communication path with the second BHE, in which abnormality is not recognized on the communication path, and

wherein the AE changing settings in the AE transfer table so as to switch an uplink signal sending path from the first communication path to the second communication path with the second BHE, in which abnormality is not recognized on the communication path, when the switching instruction frame is received, and

wherein,

on the other hand, the first BHE changing settings in the first BHE transfer table in the first BHE so as to switch a path, receiving an uplink signal from the AE, from the first communication path to the intercommunication path; and

the first BHE further changing settings in the first BHE transfer table so as to transfer a downlink signal directed to the AE received from the network to the intercommunication path, in relation to the downlink signal to the AE which has been transferred using the first communication path connecting the first BHE to the AE, and

wherein a sub-tree having a sub-tree structure in which the second BHE of a standby system by passing a failure

point being placed as a top is built under the first BHE of an active system, and communicating between the AE and the first BHE of the active system is relayed by a standby system path via the second BHE of the standby system.

10. The communication network configuration method according to claim **9**,

wherein, in a case where the AE has already been connected to the first BHE via the second communication path and the second BHE due to a failure regarding the first communication path connecting the AE to the first BHE,

when the second BHE detects a failure regarding the second communication path according to stop of periodical reception of a connection checking frame which is transmitted from the AE to the second BHE,

the second BHE sends a switching request frame to a third BHE using the intercommunication path,

wherein,

when the third BHE receives the switching request frame transmitted by the second BHE,

the third BHE recognizes that some sort of problem which disrupts continuous communication between the AE and the second BHE occurs;

the third BHE makes the third communication path connected between the AE and the third BHE valid as the main signal path in a third BHE transfer table in the third BHE, sets a communication path directed to the AE using the intercommunication path connecting the first BHE and the third BHE for a downlink signal to the AE, and changes settings so as to set a transmission path by the intercommunication path for an uplink signal from the AE; and

the third BHE further sends a switching instruction frame to the AE so as to switch an uplink signal sending path from the first communication path to a third communication path with the third BHE, in which abnormality is not recognized on the communication path, and

wherein the AE changes settings in the AE transfer table so as to switch an uplink signal sending path from the first communication path to the second communication path with the second BHE, in which abnormality is not recognized on the communication path, when the switching instruction frame is received, and

wherein,

on the other hand, the first BHE changes settings in the first BHE transfer table in the first BHE so as to switch a path, which receives an uplink signal from the AE to the intercommunication path connected to the third BHE; and

the first BHE further changes settings in the first BHE transfer table so as to transfer a downlink signal directed to the AE received from the network to the intercommunication path connected to the third BHE, in relation to the downlink signal to the AE, and

wherein a sub-tree having a sub-tree structure in which the third BHE of a standby system by passing a failure point is placed as a top is built under the first BHE of an active system, and communication between the AE and the first BHE of the active system is relayed by a standby system path via the third BHE of the standby system.

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